DOCTOR OF PHILOSOPHY

A Periodic Table of Movements

Two Reference Frameworks for Quantifiable Emotion, A Practice Based Investigation of Human Expressive Movement and Gesture

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Two Reference Frameworks for Quantifiable Emotion, A Practice Based Investigation of Human Expressive Movement and Gesture

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Declaration

This is to confirm that Iwona Hrynczenko is the author of this thesis and unless otherwise stated, the author has consulted all the references cited. The work, of which this thesis is a record, has been created solely by the author, and this research has not previously been accepted for any other higher degree.

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Abstract

The development of sensor-based technologies has opened up avenues for a dialogue between the body and digital spaces, uncovering new possibilities for cross-disciplinary projects and engagements that demand new methods compatible with the ethos of embodied practices, which, in turn, require new approaches and tools.

This research seeks to address this need by examining the quantifiability and visual properties of embodied emotion through a multi-layered study of human movement and gesture. It is an elaboration of scientific and artistic research methods, intended to answer the following principal question and related sub-questions:

How can emotions, expressed via whole-body movement be visually documented and archived as a reference framework to stimulate the use and studies of expressive gesture in digital environments?

As a consequence the following sub-questions become relevant for this research: The first, ontological in its nature; what is expressed emotion? and the second, methodological; how can bodily expressed emotions be visualised and quantified?

To answer these questions, the research is divided into three parts. Drawing on phenomenological interpretative inquiry and heuristic methodology, whole-body emotive expressions are documented and analysed from multiple perspectives: body, expressiveness, time, space volume and their correlations.

The first part contains information related to video data collection and the database design. The second part describes silhouette extractions of whole body emotive expressions and an online survey where the visual perception of visual data is measured. The third part of the research contains visual and quantitative data analysis providing the basis for visualisation of the four archetypal emotions: anger, fear, joy and sadness and their relationships. In this process, a multi-method approach was adopted combining both qualitative and quantitative methods adopted from sociology and cognitive science. The contextual review, where virtual embodiment and interactivity are explored build on the aesthetics of performance within new technology, highlighting the adaptability of the methods used in performance art to the field of game design.

The results of this research and contribution to knowledge reside within both the ontological and methodological approaches used within this study. The ontological resides within the development of two reference frameworks: a correlation table defined as the Periodic Table of Movements (PTM) and a PTM database. The PTM database is a synthesis of embodied emotion data derived from multiple visual representations such as colour, shape, space, volume, time and intensity, whereas the relationship between expressions is visualised in the PTM correlation table. Within the context of an educational framework, the database also provides visual concepts of emotion as epistemic objects for analysis and experimentation. It is a starting point for future cross-disciplinary studies and research on emotions in the context of embodiment and digital technology. The novel methodology of this research contributes to a number of fields with new methods and models of enquiry, grounded within a hermeneutical interpretation driven by artistic development. This exploration opens up a holistic approach to future studies and research grounded in a multimodal attitude to knowledge acquisition.

Glossary and Abbreviations

ANOVA Analysis Of Variance in Statistics is a method to compare differences of means between more than 2 groups. It is accomplished by looking at the variation in the data and where the variation exists. The ANOVA method compares the amount of variation between the groups with the amount of variation within groups. The method is used for both observational and experimental studies.

Balsamiq Mocaps Balsamiq Mocaps is a computer program developed by the company Balsamiq. It is a rapid use tool for wireframing, which is a quick sketch method for the design of interfaces and structures for websites.

Bitmap data Bitmap data specifies the attributes of a raster graphics image, which refers to computer images composed of small rectangular pixels – i.e. bitmaps (points of colour).

Butoh A performative act that associates with a dance form, a poetic and surreal choreographic language, pioneered in post-war Japan by Hijikata Tatsumi (1928 - 1986). Butoh is a different ' kind of theatre that happens inside' Yeung (2002 p. 15). The distinctive characteristic for butoh is that it is expressing intense emotions through slow and sometimes deformed movements, connected to a devotional state of mind. Butoh has developed in different directions during the last twenty years, however the two main paths both refer to the body form as an expression of feeling. One of them is based on Hijikata's statement that 'Life catches up with form' (Ohno; 2004) declaring that feelings could be intensified through the body form based on particular body shapes and postures. The second is Ohno's; 'Form comes of itself, only insofar as there is a spiritual content to begin with.'(Ohno, 2004)

Chronophotography
A photographic technique that captures movement in a sequence of photographs, which are subsequently arranged as animation cells or layered within a single frame. The Chronophotography technique aims to exhibit the successive phases of motion.

Circos Circos is an open source software package developed by Krzywinski *et al.* (2009) originally designed for visualization of genomic data. Circos is based on the pearl programming language visualising data in a circular layout, which provides an overview of the correlations among the groups in one dataset.

Computer Vision Computer vision is a scientific field that utilises methods for extracting information from images based on the acquisition, processing, classification, analysis and understanding of images. In general, it is high-dimensional data from the real world computed in order to produce numerical or symbolic information required for the decision processes of artificial systems (Szeliski, 2011).

Connectivity matrix

In mathematics and graph theory, connectivity or adjacency matrix is a method of representing relationships of data visualized by nodes of a graph that are connected to other nodes. This could be represented in a matrix table where the rows are equal to the columns and connections are represented by "1" for connection and "0" for the lack of connection among nodes.

EMES An Expressive Movement Evaluation Survey was conducted online during this research.

First person shooter

Refers to a video game genre centred on gun and projectile weapon-based combat where the player experiences the action through the eyes of the main character, i.e. in the first-person perspective.

Google spread sheets

Google Spread sheets allows the creation of charts and graphs using Google's online suite of tools such as Google Charts that can extract data from Google Spread sheets.

Green screen Green Screen is a technique used in video clip or image processing to replace all green (or blue) colours with a new background or to remove an object from the background using a computer program known as Chroma Key Colour Transition.

HCI Human-Computer Interaction, is a field of study in the area of computer science encompassing cognitive science and human factors engineering focussing on the interface design and evaluation of interactive computer systems used by people.

ISilhouette v. 1.0 iSilhouette produced by Chv-electronics is a video filter for video editing programs: Final Cut Pro and Final Cut Express that colorizes the silhouette of an object. The filter defines up to four colours that are used for shape creation and can colorize the shape and the surrounding areas by two definable colours. Additionally the borders of the shape can be cleaned of superfluous pixels and colourized.

Kinaesthesia Kinaesthesia originates from the Greek word; kinein 'to move' and aisthēsis 'sensation' and refers to ‘awareness of the position and movement of the parts of the body by means of sensory organs in the muscles and joints’. (Oxforddictionaries.com, 2014).

Kinaesthetic perception

Kinaesthetic perception is an awareness of moving and movement, i.e. sensing through the body; its position, weight and muscle movement.

Kinect Kinect is Microsoft's motion sensor add-on for the Xbox 360 and Xbox One gaming consoles using gesture recognition that enables the tracking of player movements. The devices are equipped with depth sensors, RGB cameras and microphone arrays. The players’ movements are detected via infrared motion sensors and speech recognition software allows the system to understand spoken commands. Kinect provides a natural user interface (NUI) that allows users to interact intuitively and without any intermediary device, such as a controller.

Kinesphere Rudolf Van Laban (1966, p.10) defines the kinesphere as; ‘The sphere around the body that a dancer can easily reach while standing still that moves with the person's traceform in space’. Traceform is a path created by dancers' limbs in space. Kinesphere is related to the theory behind Laban Movement Analysis (LMA).

Kinaesthetic empathy
Kinaesthetic empathy is a key interdisciplinary concept in our understanding of social interaction and communication in creative and cultural practices ranging from art through entertainment and sport to physical therapies (Reynolds and Reason, 2012. p.18).
Originates from Lipps’ theory of' “einfuhlung ". Lipps (1851-1914) maintained that when observing a moving body, such as a dancer, spectators could experience an inner sense of imitation, reflecting the events they observed.

LimeSurvey LimeSurvey is a free and open source on-line survey application written in the programming language *PHP* based on a relational database management system *MySQL*. LimeSurvey is distributed under the GNU General Public License as web server-based software that enables users to develop and publish on-line surveys, and collect responses, without programming knowledge (LimeSurvey, 2012).

Max/MSP/Jitter Is a visual, modular programming suite of software software for music and multimedia applications developed by Cycling '74.

MDA Mechanics-Dynamics-Aesthetics, a framework used for games analysis and design. *Mechanics* encompasses the formal rules of the game that define how the game is organised, what actions the players can take, the conditions Mechanics forms, the algorithms and data structures in the game engine. *Dynamics* describes how the rules act in motion, acting on player input and working in concert with other rules of mechanics. In programming terms, dynamics is the “run-time” behaviour of the game. *Aesthetics* describes the player’s experience of the game, the player’s emotional responses: enjoyment, frustration, discovery, fellowship, etc.

Mean The Mean (Average) measures the central tendency in statistics, calculated by dividing the sum of the values in the data set by their number.

Mirror neuron **A** Mirror neuron was observed in the ventral premotor cortex of a monkey by Giacomo Rizzolatti and collaborators in 1992 (Rizzolatti and Fabbri-Destro, 2010). It is braincell that fires when action is preformed and also when the same action of another person is only observed. Several research findings in neuroscience confirm correlations among mirror neuron movement perception and empathy, defined as *kinaesthetic empathy* (Keysers. 2010, Rizzolatti and Fabbri-Destro, 2010).

Mocap capture
Mocap capture involves measuring an object's position and orientation in physical space, then recording that information in a computer-usable form. Objects of interest include human and non-human bodies, facial

expressions, camera or light positions, and other elements in a scene. A studio set-up typically uses eight cameras, with up to 24 for multiple capture, calibration of capture area, capture of movement (based on real-time performance), clean-up of data, post-processing of data (that can appear as two-dimensional or three-dimensional objects) (Furniss, n.d.).

MySQL MySQL commonly found on Web servers is an open source relational database management system. It is based on the structured query language (SQL), which is used for accessing, adding, removing, and modifying information in the database. MySQL may include Web pages referred to as "dynamic" that access information from a database, which refers to database-driven websites (Techterms.com, 2007).

Network analysis Network analysis examines the structure of relationships between entities in a network.

Nordplus Programme
The Nordic Council of Ministers' Nordplus Programme is targeted at higher education institutions and organisations that focus mainly on education and lifelong learning. 'The Nordplus Programme comprises mobility grants for students and teachers, intensive courses for students to experience more than the usual classroom, teachers learning from each other and networking activities for developing innovative projects. From the participating countries: Denmark - including Greenland and Faeroe Islands -, Estonia, Finland - including Åland -, Iceland, Latvia, Lithuania, Norway and Sweden'. (Nordplus online, 2007).

NUI Natural User Interface (NUI) is a system for human-computer interaction that the user operates through intuitive actions related to natural, everyday human behaviour and without any intermediary device, such as a controller.

Open presence In the Buddhist philosophy open presence is a state of unconditioned awareness, an inherent potential that every being has, which requires practice to attain. 'Open presence is aware of all the disparate displays inherent in its own nature, referred to as an unbounded wholeness' (Garfield and Edelglass, 2010, p. 275).

Paratheatre 'The term "paratheatre" was coined by the Polish theatre director, Jerzy Grotowski, to address a highly dynamic and visceral approach to performance that intended to eliminate traditional divisions among spectators and performers' (Alli, 2013 unpaged).
Paratheatre was acted outdoors in the forests of Poland as non-performance events where the on going intentions were to find individual movements, actions and group rituals for encouraging unprecedented interactions. These are invoked by sound and word or evoked by feeling and motion 'strong spiritual and visceral resonances that — with enough commitment — erupt in spontaneous gestures, movements, patterns of motion, sounds, vocal creations, characterizations, and stories to be shared with others' (Alli, 2009 unpaged).

Personal space Personal space is defined by Rudolf von Laban (1879-1958) as *kinesphere,* which is the space around us where, without changing the location, we can stretch out our limbs.

PHP	PHP originally stood for Personal Home Page, created by Rasmus Lerdorf in 1995. Now, PHP refers to Hypertext Preprocessor, a server-side scripting language designed for web development but also used as a general-purpose programming language. PHP is installed on more than 244 million websites and 2.1 million web servers (Php.net, 2013).
Plots	Plot is a function on a graph, 'which is a visual representation of the relations between certain quantities plotted with reference to a set of axes' (Researchgate.net, 2014).
PNG	Portable Network Graphics is a raster graphics file format that supports lossless, portable, compressed image data. Nowadays it is the most commonly used format on the Internet that supports indexed-colour, grey scale, tricolour images and optional transparency (Iso.org, 2012).
Proxemics	Proxemics, the study of the human use of space within the context of culture.
QR-Codes	Quick Response Codes are readable optical labels that contain information about items to which they are attached, often, with a link to a related website. QR code consists of black elements arranged in a square grid on a white background, which can be read by a smart device (often a camera in a mobile phone).
QoM	Quantity of Motion, is a 'normalized value for the total movement in a current video frame. QoM = 1 means that all the pixels in the video change from one picture to another, QoM = 0 means that there is no movement in the picture since the previous frame' (Jensenius, 2013).
Scatter plots	A scatter plot or scatterplot, is a graphical representation of data that uses x and y coordinates to display data points providing a visual relationship between these two variables. The relationship betwen the two variables are termed their correlation.
SD	Standard Deviation in statistics shows how much variation exists from the mean. Mean is the average of the numbers based on a central value of a set of numbers calculated by dividing the sum of the values in the set by their number. 'A low standard deviation indicates that the data points tend to be very close to the mean (also called expected value); a high standard deviation indicates that the data points are spread out over a large range of values' (Gotelli, 2014, unpaged).
Somatic	The body as a whole: bodily, corporeal, physical. 'Originates from Greek sōmatikos, from sōma 'body' and Relates to the body as distinct from the mind' or spirit (Oxforddictionaries.com, 2014).
SPSS	IBM software used for statistical analysis and data management.
VideoAnalysis	VideoAnalysis is software developed at University of Oslo by Jensenius (2007), providing a non-real-time video analysis of quantitative features of movement contained in the video producing a quantitative data in form of a "txt" data file.

Website Wireframe A Website Wireframe, also known as a page schematic or screen blueprint is a visual guide that represents the skeletal framework of a website (Brown, 2011, p. 166).

XML Extensible Markup Language (XML) is a markup language that defines a set of rules for encoding documents in a format that is both human-readable and machine-readable. The structure of the language is divided into markup and content. The XML design focuses on documents, but is also widely used in web services on the Internet (W3.org, 2013).

Z-Project Z Project is a part of imageJ software, used for analysing a stack (a group of images) by applying different projection methods to the pixels within the stack. This process is used to highlight specific data from the stack.

1 Introduction

Our own body is in the world as the heart is in the organism: it keeps the visible spectacle constantly alive, it breathes life into it and sustains it inwardly, and with it forms a system (Merleau-Ponty. 1962, p. 203).

1.1 Rationale

Despite the growing and continuous stream of literature within the field of cognitive research on emotional expressions, there has been comparatively limited research produced within the context of the visual properties of embodied emotion associated with games. Although there has been a proliferation of work, by digital games researchers such as Isbister (Isbister 2006; 2008; 2011), the field is far from mature and previous studies have focused almost exclusively on facial expressions.
The development of motion sensor-based technologies and the growing number of virtual world participants, highlight the need for a deeper dialogue and understanding of the relationship between physical bodies and digital spaces. As a result, the interest in kinaesthetic and visual properties of emotion has opened up new possibilities for cross-disciplinary projects and engagement that demand new methods, which, in turn, require new approaches and tools (Hrynczenko and Knuutila, 2014). This research seeks to address these issues by interpreting and identifying human emotive gesture and movement as visual and quantifiable epistemic objects, collected in an online database and intended as a tool for exploration, learning and research. By combining both artistic and scientific methods, challenged by subjective and objective approaches, this study showcases a holistic attitude underpinned by heuristic methodologies that originate within the field of phenomenology. This background reflects the interdisciplinary character of the research, placed at the crossroads of real-time performance, human-computer interaction (HCI), data visualisation, pedagogy, game design and graphics.

1.1.1 Context From a Broad Perspective

Video games are a growing phenomenon that in a relatively short time have become distinctive media and cultural forms, as well as a platform for social interaction. Thanks to Microsoft Kinect's release in 2010, this optical, motion sensing input-based technology offered the potential of more sophisticated, natural user interaction combined with greater understanding of the human body as experienced within a digital context. The issue of conflict between human emotion and emotional representation within digital spaces has become highly relevant in discussions amongst psychologists, philosophers sociologists and artists. This ongoing dialogue is providing forums for information exchange and introducing a more holistic approach for future technical developments and the growing requirements of virtual worlds. Jane McGonigal (2011), director of game research and development at the Institute for the Future (U.S.), reveals that in the global gaming landscape the population spends 3 billion hours a week playing games. In her book*, Reality Broken: Why games make us better and how they can change the world*, she declares in reference to the inhabitants of virtual worlds and online games by quoting Castronova's (2007) famous statement, envisaging a near future:

> I think the twenty-first century will see a social cataclysm larger than that caused by cars, radios, and TV, combined… The exodus of these people from the real world, from our normal daily life, will create a change in social climate that makes global warming look like a tempest in a teacup (Castronova via McGonigal, 2011, p. 3).

Karhulahti (2013) distinguish within the scope of his kinaesthetic theory of video games between the players' challenges during game play as ‘kinesthetic’ and ‘nonkinesthetic’. Karhulahti highlights the one almost unexplored field in game design, namely, the physical effort during gameplay in relation to player's negotiation with the game's Mechanics and Dynamics. There are games such Wii Sports (Nintendo, 2006), Just Dance 5 (2014) and Kinect Sports (Microsoft Game Studios, Ubisoft, 2010) and many others, however, these games often build upon simple reflexive motor skills, negating cognitive challenges for the player. Karhulahti (2013) clarifies the distinction of gaming efforts in terms of physical, and cognitive skills in which the 'Kinestetik' game requires the player’s physical and cognitive input to overcome the challenge of the game. I apply his terminology to distinguish the differences. In a ‘nonkinesthetic’ game, there is no unity between perception and movement. However, there are limited connections between emotion and the expressive gesture, but the interaction between the player and the game is usually based on small and mechanical movements, where at the same time the players are exposed to a range of different modalities of emotional engagement (Calleja, 2011; Lazzaro, 2004).

Physical movement as an expression of emotion is one of the most important communication tools used by humans (Plutchik, 1980; Dourish, 2001; Crane & Gross 2007). According to neuroscientist Daniel Wolpert (2011), in his research on corporeal movement and sensory prediction, the majority of the brain has evolved not to think or feel, but to control movement. Similarly, Mazzola *et al* (2012), in relation to the new technology and neuroscience, highlights the important link between action and perception, as 'the integral of all the dimensions that define our physiological existence as a space-time of action and perception. It is the global interface with extensional reality of the human existence.' (Mazzola *et al*., 2012 p. 75). We are most of the time in a perceptual engagement with our surroundings. Taking this thought into the perspective of the human body; our 'first and most natural instrument', our bodies form actions, but they are also formed through actions (Mauss, 1979/1934 p. 104). We are in a constant cognitive and physical relationship with the world we engage in, real or digital, in which the affordances of the world affect our actions (Gibson, 1977), our bodies execute them, as well as how they adjust to the trajectories of these actions (Bernstein, 1996).

The neuroscientific discoveries of mirror neurons points out that a relationship exists between movement perception and the empathetic reaction (Rizzolatti and Fabbri-Destro, 2010; Keysers, 2010). This finding introduced kinaesthetic empathy in the broader scientific context and has formalised the issue of expressive movement and gesture in new research iterations beyond neuroscience, extending it to many areas including philosophy, cognitive science, psychology, medicine, ethnography, art and performance arts. From the perspective of phenomenology, Van Manen (2007) clarifies the relationship among empathy, cognition, action and perception by referring to the semantics of "pathic" (em-phatic, sym-pathic):

> ..the first important point is that the terms empathy and sympathy suggest that this understanding is not primarily gnostic, cognitive, intellectual, technical — but rather that it is, indeed, pathic: relational, situational, corporeal, temporal, actional (Van Manen, 2007 p. 20).

In summary, video games are a growing phenomenon involving significant numbers of users who enjoy gameplay emotionally without the effort necessarily of direct physical engagement. ‘Newzoo and GlobalCollect estimated that there were 1.78 billion gamers worldwide as of August 2014’ (Statista, 2015, unpaged). Researchers from psychology, sociology and Human Computer Interaction connect expressed emotion with communication skills, whereas findings from the neurosciences connect embodied gesture with empathy. Game theory researchers point to a lack of effort in gameplay that could challenge both the cognitive and physical skills of the player. Simultaneously, the development of new 3D, optical, motion sensing-based technologies are now providing more sophisticated interfaces for the interpretation of human expression and behaviour.

What is needed, is game design that takes all these parameters into consideration. As a teacher in animation and character design at the Game Design Department at Uppsala University, Sweden, I consider emotional expressions in games from the perspective of the visual properties of emotions. These are divided by; shape, space, volume, time, intensity and the communicative properties of expressions. These visual properties have a dual use both for game graphics and game design. For game graphics, the different emotional expressions of game characters can enhance the storytelling aspect of the game. For game design, due to the visual properties of emotions that can be visually read by optical, motion sensing input devices, game engines can create responses to the input of the player's emotional expressions.

1.1.2 The Philosophical Point of Departure

This research evolves from the body itself, which is the most subjective approach to the world and within the context of this practice-based enquiry, I use it as a mediator. During my wide-ranging work in the fields of multimedia and games, I have reflected on the gap between computer and user in terms of interface design, as well as the general lack of media content that can engage whole body movement. Looking at human-computer interaction in game design, it is evident that the technology is seen as the dictating norm. It seems that by automatisation of the user's movements we are adapting the human body to the computer's engine; to the machine as an ultimate reality, a perception inherited from industrialism.

Elaboration of this notion may require clarification of my point of view. During the last few decades, new possibilities have been created for physical expression within digital domains, yet during the development of these new digital cultures interaction with the physical human body seems to have been left a step behind. The reason for this gap can be explained by looking back to the early days of computer development. The interface design for human-computer interactions (HCI) developed in the information age, and at the time of digitalisation, specifically speaks to the Cartesian statement: "I think therefore I am." The objective of the present research, however, is based on the theory: "I am because I interact with the world through my physical body," followed by: "My body is my memory container."

This theory has crystallised during my four decades as a performer and is grounded in performance methods developed by Grotowski and the methods used in *Butoh* (see glossary). It is therefore subjective and based on personal experience, as well as on knowledge developed by non-western cultures. The psychologist, Seitz (1993), formulates the idea less controversially in the article titled: *I move ... therefore I am*:

> We are caught up in a persistent, Cartesian dualism that we are comprised of two fundamentally different things - an extended substance (body) and an unextended substance (mind). But the mind and the body are two different aspects of the same thing. The brain systems for movement and the brain systems for thought and emotion are intimately connected to each other. Thus we are literally a thinking (and feeling) body. Followed by his conclusion: We do not simply inhabit our bodies, we literally use them to think with (Seitz. 1993, p. 1).

The idea of the body as a vehicle for human perception and consciousness and its first person point of view is reflected in the philosophical ideas of Phenomenology, introduced in this form to the western world in the early 20th century by Edmund Husserl (1859–1938) in the attempt to structure human experience as a part of the human consciousness. Phenomenology refers to the study of "phenomena" or appearances of things, and is linked to ontology as described by Heidegger (1889–1976) who extended the terms of existence to 'beings' in relation to a structure. Heidegger's concept of Da-sein, or "being-in-the-world", refers both to phenomenology and existentialism based on the influences from the East via Okakura Kakuzō (1862–1913) (Imamichi, 2004), reflecting a concept of 'being' that is disclosing the world. Therein, Heidegger criticises the way that western cultures split things into subjects and objects (Dreyfus, 1991, p. 49).

Da-sein is a more nuanced form of "being-in-the-world" which applies to the moods we feel as a significant part of the human perception of the world. From Heidegger's point of view, “being-in-the-world” also envelops interpreting and understanding the world in terms of possibilities. Both of these concepts are amplified in the virtual world but are deprived of corporeal perception. Both phenomenology and ontology are influential in the present research by representing two correlated philosophical points of view connected to the holistic approach during the practice-based inquiry.

The phenomenology of embodiment introduced by Husserl, linked to the notion of kinaesthetic consciousness, describes ‘subjectivity that is itself characterized in terms of motility, that is, the very ability to move freely and responsively’ (Husserl via Behnke, 2011, pp. I). Heidegger's ontological approach connects to structures in the context of a system and entities, where a ‘being’ exists based on its functions in relation to other ‘beings’, and can therefore be grouped according to the similarities and differences in a system. Following Heidegger, the French phenomenologist Merleau-Ponty (1962) presents the idea of the body as the engine to perception in the form of a metaphor:

> Our own body is in the world as the heart is in the organism: it keeps the visible spectacle constantly alive, it breathes life into it and sustains it inwardly, and with it forms a system (Merleau-Ponty, 1962, p. 203).

In the course of this phenomenological perspective I have used my own background as gamer, performer, media artist and teacher and, in the light of research from neuroscience, I have drawn a worrying conclusion. Specifically, in the longer term, the split between motion and emotions affects the kinaesthetic perception, which specifically may relate to the inhabitants of virtual worlds. According to Zaner (via Behnke, 2011, unpaged), the kinaesthetic consciousness is embodying human reality as a “continuously on-going act”. In contrast, the users/players “presence” in virtual worlds is mainly reduced to cognitive perception. To be present requires the sensitivity and responsiveness of the whole body, a statement based on the holistic ideas of phenomenology. Similarly, from various disciplinary perspectives, theoretical discussions about embodiment v. technology have emerged in last two decades (Damasio, 1994; Dourish, 2001; Gallagher, 2005 and Gibbs, 2005).

The gaming community also expresses a similar belief in the need for embodied engagement with virtual worlds. According to the study: *The Future of Gaming: A Portrait of the New Gamers*, by Latitude Research (2011), it has been shown that the game enthusiasts prefer to take part in games that involve gestures and body movement. In the section of this study, ‘*How Would You Like to Interact with Games in the*

*Future?' (*Latitude Research 2011, p. 5), using infographics, this desire for embodied engagement was visually presented, highlighting the gap not yet covered by the game industry. Game mechanics and content can be developed on the basis of existing perceptual movement recognition interfaces. This problem is also emphasised by game developers and researchers; for instance, researchers in the HCI community have conducted studies demonstrating that physical games increase engagement (Bianchi-Berthouze *et al*., 2008) and social interaction (Lindley, *et al*., 2008). Several studies point to the general effects of presence or absence of body movement in gaming, but do not give detailed descriptions of the type of motions or the effects created by them (DiMauro and Isbister, 2009, p. 1).

My departure point in this thesis is that virtual environments, especially games, can provide a better understanding of human behaviour, increase cognitive and visual perception, increase levels of student engagement in education (Sheldon, 2011), and that cooperative play modes can increase positive social behaviour (Bianchi-Berthouze *et al.,* 2008; Lindley *et al.,* 2008; McGonigal, 2011; Schmierbach, 2010). Moreover, drawing on the gamer and philosopher Grant Tavinor's (2009) arguments, he indicates that games contribute to human activity by engaging in the same kind of issues that are usually associated with the arts:

> ...aesthetics, representation, narrative, emotional engagement, and morality, which have been the focus of the philosophy of the arts (Tavinor, 2009, p. 13).

In summary, in my critique of the disembodied games I intend to demonstrate that a holistic approach is needed while emphasising that human bodily expression should be a vital consideration in all digital environments. This includes movement and gesture to reconnect and to especially emphasise embodied perception since the virtual environment is the medium that allows embodied interaction with the content. In particular, in games, it is important because these are a native form of computer art that exclusively use the capabilities of behaviour simulation. I also highlight the need for movement-based game mechanics in synergy with narrative content that can develop on the basis of human expressive movement and gesture. Similarly within the context of HCI Dourish, (2001, p. 2) also pointed out; '...we need new ways for human-computer interaction that build on our needs and abilities'.

1.1.3 The Visual Artefact as a Pedagogical Point of View

Emotion recognition and visual perception are part of our everyday vocabulary of communication, and in this investigation they are grounded in Robert Plutchik's Psychevolutionary Theory of Emotion (1980). Yet, within an educational design context, tools to elaborate on body language are to a greater extent omitted, both in terms of game graphics and game aesthetics. As a consequence and based on my own teaching experience, students' knowledge is lacking as to how particular emotions are expressed. This situation results in 'uncanny' movement schemes of game characters and in particular mainly focussed on 'nonkinaesthetic' games.

Analogously, a biased relationship to the human body, in terms of gender representation in games, points to a visual culture disconnected from reality and real bodies, which unfortunately often dominates game graphics. A reflection of, or maybe one of the reasons that sexism dominates the games sector and infects the gender-related discussion in the socio-cultural atmosphere of games related communities. The phenomenon known as the *Gamergate controversy,* widely discussed in the news media in the last two years (Dewey, 2014), highlights endemic socio-culturally related problems within video games culture. A phenomenon in which the 'collective representation' of the human body in games plays a significant role (Durkheim, 1982).

In terms of bodily expressions in games, there is a lack of knowledge as to how the patterns of emotive expressions of players could be used in game design in connection with game *Mechanics* and *Dynamics* to empower game *Aesthetics (MDA)*. This situation makes full use of the possibilities offered by optical, motion sensing input devices although difficult to integrate into gameplay. Therefore, most of today's games are 'non-kinaesthetic', i.e. disembodied in terms of cognition, physical challenge (Karhulahti, 2013) and feedback of the player's physical (full-body or gestural) actions. However, I believe that this position can be changed, by starting at the educational level!

The cognitive and pedagogical approach is usually the first step in serious game design. Mainly, in the context of instructional design, which, in this case, applies to database design for educational purposes. However, my aim here is to account for visual artefacts in the process of learning and knowledge acquisition within the context of a socio-cultural environment. Acordingly, this can be realised by referring to Jean Piaget's (2001) theory of cognitive development, and Lev Vygotsky (1978) and Jerome Bruner's

(1977) theories grounded in cultural theory and social interaction. Piaget's theory, in a very simplified version, focuses on children's cognitive processes in which he argued that children only learn through the interaction with their environment. Through an iterative learning process, they construct the world by interacting with it, learn by mistakes, and then reconstruct the world again by adding a new knowledge. Vygotsky contributes to a socio-cultural perspective, the main point of his theory is that learning starts as a social activity and is influenced by the interaction with the environment. All functions of child's cultural development appear first, on a societal level, and later, on the individual level in which learning is a prior state of development. Bruner's theories builds on the concept that humans interpret the world based on its similarities and differences which he connects to the long-term memory, referred to in the context of his model of long-term memory.

In today's western civilisation, we have become more than ever dependent on visual artefacts. As technology expands, this growing visual culture and visual communication become our mode of discourse and a part of our social and cultural identity. I consider a database of expressive, movement and gesture as a tool to stimulate the use and studies of embodied emotion in digital environments. This database, apart from the motion data, is mainly built on visual artefacts; these are not just visual objects to look at but a collection of visual and qualitative data objects open for interrogation, manipulation, and reinterpretation. It is mainly, a pedagogical tool for the exploration of the properties of human emotion and an instrument for discussion on the representation of the human body. From the perspective of cognition and learning processes, visual input has a critical role to play in how we remember and retrieve information, how we learn and store knowledge in the memory, and how we use this knowledge in a socio-cultural context.

In formulating this argument, I draw on theories that reflect the process and models of learning; the often misinterpreted early research of Edgar Dale (1954, 1969) divided information we learn within a spectrum from the concrete to the abstract. This adaption of Dale’s Cone (figure 1.1) refers to the degree of abstraction in which knowledge is passed to the learner via media and experiences. Higher abstraction occurs at the top of the cone, lower abstraction at the bottom. The main findings of his research points out that knowledge stays with the learner if more senses are engaged in the learning process, such as: hearing, seeing, touching, smelling, tasting together with other embodied participatory actions. My intention here is to highlight learning processes through actions and visual artefacts in which I highlight the importance of artefacts within an educational and research context. Consequently, this is connected to the need for learning frameworks that could provide the possibility for students in games art and design to elaborate and reason about human body representation and emotive gesture meaning.

The connection between cognitive, visual and sensory-motor memory was explained by Atkinson and Shiffrin's (1968) memory types, which are involved in information processing and as proposed in the Atkinson-Shiffrin model. They categorised these components as: sensory memory, working memory (also known as short-term memory), and long-term memory. According to Atkinson's and Shiffrin's (1968) theory, sensory memory collects stimuli from all our senses, stores it in registers one for each of five senses and buffers the information for a very brief period of time. This process is outside of our cognitive control. In general, if the information is ignored then it disappears relatively quickly from our memory buffer. Although, if perceived then the experience is passed to the working memory, where the information is contextualised and passed to long-term memory as episodic knowledge (Tulvig, 1985).

The working memory has a dual capacity by working mainly as a buffer storage for verbal and textual stimuli and also for visual and spatial stimuli. Essentially, the working memory is where the information is sorted and contextualised creating linked memories so they could be consciously retrieved when triggered by any aspect of the experience.

The long-term memory, where the knowledge stays and can be retrieved, contains three types of memory: procedural, episodic and semantic (Tulvig, 1985). Procedural memory collects information about how to physically perform different skills, also known as motor skills e.g. how to walk. Episodic memory connected directly to sensory input is involuntary, whereas semantic memory stores processed and accomplished information from working memory.

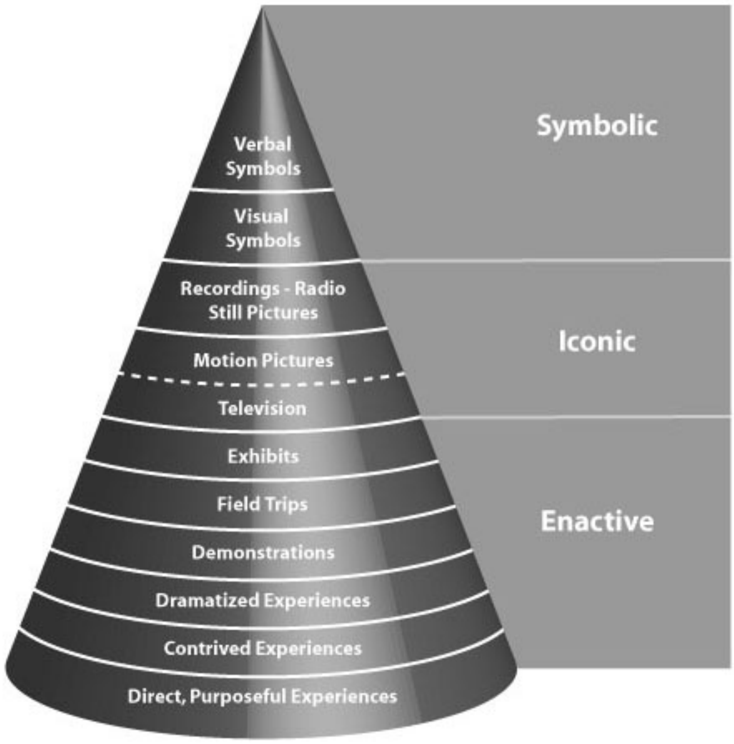

Figure 1.1 Adapted from: Cone of experience, Dale, 1969 and long-term memory Bruner, 1974.

Bruner's (1974) model of the development of learning categorizes how information is stored in the long-term memory as follows:

> Symbolic—memories of concepts, ideas, thoughts, transferred to symbolic code such as language or mathematics
> Iconic — memories of perceptions such as visual images, sounds and smells
> Enactive — memories of actions

Bruner's (1974) model and its relationship to Dale's (1969), is shown on the right side of figure 1.1. According to Bruner (1974), the important issue is to teach how things are connected, i.e. the contextualization of knowledge. The knowledge acquisition process is taken into consideration during this research in the context of the pedagogical approach. The visual context of the embodied knowledge responds to the movement documentation, evaluation and categorization process.

Bruner's (1974) approach connects this type of information to the processes of information storing in the long-term memory, which highlights particular correlations. According to his view, procedural memory depends on enactive representations, episodic to iconic and semantic memory to symbolic representations. Both enactive-procedural and iconic-episodic memories support symbolic-semantic memory in the learning process. To illustrate the point, learning complex cognitive tasks with the help of visual artefacts and physical actions, aids the storing of memories and their retrieval. For example, actors often memorise long sections of dialogue by visualising situations and by using gestures, which helps them to retrieve the dialogue through repeating their actions on stage. Episodic memory ties everything we learn to a particular context of events in which we first experienced it whereas procedural memory depends on the repetition of action and is processed without our conscious involvement. These models are to some extent confirmed by neuroscience (Marois, and Ivanoff, 2005 via Khan, 2012, pp. 116-118), although on-going research in neuroscience continues to reveal new and more complex paths of memory and knowledge acquisition.

During the last decade, the discourse on the multimodal character of learning and multimodal literacy has continued within several publications, extending the knowledge of this approach to learning and research (Kress, 2010; Selander and Kress, 2010).

Building further on the importance of the inclusion of all the senses in the learning process, I refer to the theory of multimodality introduced by Gunter Kress (Kress and Jewitt, 2003; Kress, 2010; Selanderand and Kress, 2010) and grounded in communication and social semiotics, to which I refer here, as a modern approach to learning and research.
Multimodality describes a communication practice built on knowledge representations and meaning-making in terms of textual, aural, linguistic, spatial, and visual resources. These are referred to by Kress and Jewitt (2003) as modes that use: image, video, animated movement, writing, speech, gesture, or gaze in order to compose a message. The ontological entities of multimodality are described by Kress (2010) as modes that use the medium as an element in which meaning is realized and communicated i.e. film, newspaper, radio, television, theatre, a classroom. Whereas, according to Kress (2010), mode is two-layered; on the one hand, it 'is a socially and culturally shaped resource for making meaning' (Kress, 2010, p. 79). Image, writing, layout, speech, moving images are examples of different modes. Alternatively, there are semiotic modes, which are formed, as described by Kress and Van Leeuwen (1996, p. 35), '…by both the intrinsic characteristics and potentialities of the medium and by the requirements, histories and values of societies and their cultures'.

In line with this, I highlight the socio-cultural context in which all media and modes are created but also the tools used for media creation. In contemporary education and

research, the discussion on information presentation and its validity is evolving more than ever (Daston and Galison, 2007). Mainly, since the use of digital media, the Internet and network-based communication involves creating new types of modalities that to a large extent are based on visual artefacts.
Within this framework, which brings us back to the ontological character of this study, through the methods used and the discussion on the objective view of the researcher, I highlight the correlation between mode, presentation and representation. Firstly, by referring again to a more extend statement of Kress, (2010):

> Mode is meaningful: it is shaped by and carries the 'deep' ontological and historical/social orientations of a society and its cultures with it into every sign. Mode names the material resources shaped in often long histories of social endeavor. (Kress, 2010, p. 114).

Secondly, I refer to different ways we can see the scientific truth from the perspective of social, epistemological, aesthetic and ethical influence, an issue discussed by Daston and Galison (2007). In their book *Objectivity* (Daston and Galison, 2007), they provide a historical perspective on the frameworks that have shaped the objectivity of the scientific work. Their departure point is through the means of a study of scientific atlases to describe the quest for objectivity and its changes in line with technological developments. In the concluding part of the book, they reflect how today's technological development has influenced the human presence in scientific visual material that today has become 'a mix of tool box and art' (Daston and Galison, 2007, p. 415). The technical automatisation of scientific information, where both haptic and digital images dominate today, makes the images look homogenous. According Daston and Galison (2007, p. 415), there is a displacement of how today's scientific results are visualized, where the engineer's presentation become the dominant image of the observer's representation.

The Periodic Table of Movements (PTM) database contains both qualitative and quantitative data obtained through methods applied in art and science in which scientific methods were used as artistic tools of inquiry. My aim in this approach was to find the convergence between art and science in my working process. Running in parallel, throughout the thesis I discuss the position of the human body in juxtaposition to technological development and in the context of existing knowledge. The name Periodic Table of Movements is intended as both provocation and an invitation rather than a description of the database content. It should be seen more as a proposition of what more research on the visual qualities of human physical movement could provide.

As a result of the practice-based research, the PTM database was created containing artefacts developed around four emotional expressions: anger, fear, joy and sadness. The PTM database is intended to provide elaborate tools for the exploration of kinaesthetic and visual characteristics of the human body. Additionally, in the context of three specific workshops arranged in cooperation with the educational Nordplus DAMA network (se section 2.2.6 Collaboration & Collaborators), supplementary tools for movement visualisation were produced as pedagogical tools aiming to discuss and elaborate on expressive movement and gesture. However, in the context of this research, the main purpose of all three DAMA workshops was to formulate a framework for cross-disciplinary projects and data collection.

The focus of this research is to create a platform for students and teachers in game art and design. The main aim of this approach was to provide tools for learning and the exploration of aesthetics and the communicative qualities of movement and gesture at an educational level. However, since technological advancement shapes our view of how we represent and use the human body in digital environments, besides the database, a parallel investigation in the form of a contextual review was undertaken. The contextual review is used to emphasize the different perspectives of human bodily expression in a historical and contemporary context. This part of the study is an investigation that underpins the database creation by connecting the existing knowledge to each stage of the practice-based research. However, by outlining cases related to human embodied emotion, the contextual study aims to collect ideas and methods that could be inspirational for the creation of emotion driven kinaesthetic games. Therefore, the contextual review focuses on cases of emotive gesture in contemporary media and performance art that are showcasing embodied expression from multiple perspectives across the timeline of technological development. In short, the contextual research demonstrates the existing knowledge in media and performance art that is useful for game art and design.

1.2 Contribution to Knowledge

This research's contribution to knowledge resides in the novelty of the methods used to provide new insights into emotion recognition and emotional perception of whole-body movements by offering innovative visual assets, methodologies and processes. The PTM database framework provides methods for emotive expression analysis, as well as video and footage samples that focus on the visual representations of emotion. For artists, educators and game and media art students, the PTM database enables an environment for analysis and experimentation by contextualising human movement expressiveness as a live human experience. The PTM database reflects a holistic approach in relation to the Heuristic guides of Phenomenology (Van Manen, 1990) by highlighting the human body as relative to time, space and the expressiveness of body language. This approach in turn provides the basis for a holistic attitude to studies and research as a method of inquiry. Considered from a multi-layered perspective, the outcome of this research and contribution to knowledge resides within both the ontological and methodological approaches used in this study by showcasing novel techniques of movement data visualisation and original methods of inquiry.

The output of the ontological approach of this research makes a contribution with two reference frameworks aimed at the educational and research areas in the form of visual concepts of emotion as epistemic objects for analysis and experimentation provided by two frameworks: a correlation table, Periodic Table of Movements (PTM) and a PTM database. The PTM database is a synthesis of embodied emotion data spread across multiple visual representations such as; colour, shape, expressions intensity, space, volume and time. In contrast, the relationship between the four emotional expressions is visualised in the PTM correlation table based on the interpretation of qualitative and quantitative data. Additionally, this research uses contextual research as a data-gathering method for studies of the phenomenon of embodied emotion as experienced within a digital environment. The novelty of this approach resides in the duality of the contextual research, which is on one hand, is used as a contextual reference for practice-based inquiry. On the other hand it is used as a collection of case studies aimed at highlighting the value of performance art to game art and design. Through this approach, this collected knowledge targets potential recipient groups beyond its intended purpose and serves as reference and argument for the doctoral studies.

The methodological approach of this study provides new methods of inquiry grounded in a hermeneutical approach to artistic development; an opening up of a holistic approach to studies and research. The study proceeded in a multi-layered manner and contributes to knowledge by its outcomes on the one hand, derived from applying existing scientific methods to data visualization utilising an original approach. On the other hand, the contribution to knowledge resides within a novel methodological approach, by elaborating on values of subjective and objective points of view in the creation of visual epistemic objects. Through this approach, the research also appeals to the wider scientific community adding value and opening new perspectives to research mainly, by converging scientific and artistic methods as tools of inquiry.

1.3 Background and Research Questions

> *One moves the movement and forgets the movement; this is not the movement in itself. If, when stimulated by external things, one moves, it is the impulse of the being. If when not stimulated by external things, one moves, it is the movement of heaven" (Chinese Book of Life. p.58).*

As humans, we subconsciously read other people's emotions and relate to them in all social interactions. We have an alphabet and vocabulary of the spoken word but not for performed emotional expressions. In practice, the movements of bodies and objects inform our daily social, political and economic lives (Goffman, 1958 and Blumer, 1969). When using the whole body as an interface, interacting with computers in the same way that we communicate with one another in the social environment, we augment our perception by preserving the human ability for unconscious translations of movement into emotional signals. If therefore we express and confront physical emotional embodiments in the digital environment, we will not decrease or diminish the human ability to feel empathy. On the contrary, according to Freedberg and Gallese (2007), the visual confrontation with the human body opens a neurocognitive channel to self-discovery of bodily-amplified empathy. In this case, if the empathy is an "interface" to ourselves, connecting us to the collective consciousness of the human species, it is important to ensure that the emotional presence or subtlety of particular movements is not lost in the system's interpretation and translation before we "build in" the human body to technical solutions.

During the first phase of this research, several important concerns developed across contextual questions such as, ‘What is emotion?’ and how emotive gestures are perceived across cultures. Cross-cultural research on emotional expressions is mostly focused on facial expressions (Altarriba *et al*., 2003). When taking this scenario into consideration the necessity to produce a platform for more research into bodily expressions is apparent. The need to archive whole-body emotive-expressions as an elaborative platform for education and research emphasises the research subject and several consequential sub-questions arise;

How can emotions expressed via the whole-body movement be visually documented and archived as a reference framework to stimulate the use and studies of expressive gesture in digital environments?
In pursuit of this query, several questions evolved during the research process referring to both the philosophical and practical/technical issues and, therefore equally significant in the broader context.

What is Emotion in relation to bodily expressions? Are emotions expressed via movement and gesture on screen equally recognisable across the cultures? How can Emotion be explained in the context of corporeal movement in order to be measurable? Which emotive expressions have the best recognition factor? How can physical data influence virtual data and how can we visualise such complex patterns?
Which postures, emphasising emotive expressions, are best suited as key reference points for optical, motion sensing input devices?

The issues presented above could be summarised by two questions. The first ontological in its nature: “What is expressed emotion?” and the second, methodological: “How can it be quantified and visualised?”

Several circumstances, detailed in the next chapter, connected to my body of work as performer, media artist and educator in the field of game design and animation contributed to this final question and the correlated sub-questions. In this way, the research becomes an explanatory journey where practice-based project descriptions and subjective reflections during the creative process are combined with the discursive academic writing and subjective reflections of an artist. During the creative process the research evolved in a contextual confrontation format of applied methods and question formulations.

1.3.1 The Journey of One Idea

The ideas behind the PTM database came about through a series of independent circumstances, rather than a single inspirational moment. PTM crystallised to the form presented here during 2010, in the second year of my PhD studies. This occurred as an effect of the research, as well as through the recent development of motion tracking technology, specifically *Kinect*, a motion sensing input device developed by Microsoft for the Xbox 360 video game console. This partly simplified my work but also brought about some changes in attitude in the game industry and game education, in terms of natural whole-body interaction. Therefore, I found it to be important to describe the context of the idea development in order to highlight my personal motivations and concerns. These have been instrumental in bringing me to the present point.

Figures 1.2 to 1.5 show a simplified representation of the rationale of this research through visual shortcuts to the research presentation and PTM idea by displaying the answers to four questions: What?, Why?, How?, Why not?
These were used for a presentation during a JISC-AHeSSC Motion Capture Methodologies workshop at the University of Sussex in Brighton, UK, on 25-28 June 2010, and in the background of a performance documentation of *Avatar*, performed by me as a single actor in Visby at Gotland's Art Museum and during the *Tango alter Ego project* (photo documentation at Mediamatic, 2007).

During the performance, the concept of the digitally projected body was explored using mixed reality performance technology, such as on-body layered projections and a simple game engine. The performance was a simulated reality of the future, where computer screens were exchanged for 2-dimensional and 3-dimensional projections, body and gestures were the only interface and game avatars reacted emotionally. A pre-programmed digital naked body of a game avatar was situated in juxtaposition with a lonely and lost human. Here the juxtaposition was symbolic in the exploration of embodied v. disembodied, post-human v. human, information society v. empathetic emotional exchange.
The performance speculated on the possibilities or problems that technical developments might bring in the future, while pointing out at the same time the human need for and tendency towards, empathetic reactions in digital environments such as games or in relation to humanoid robots.

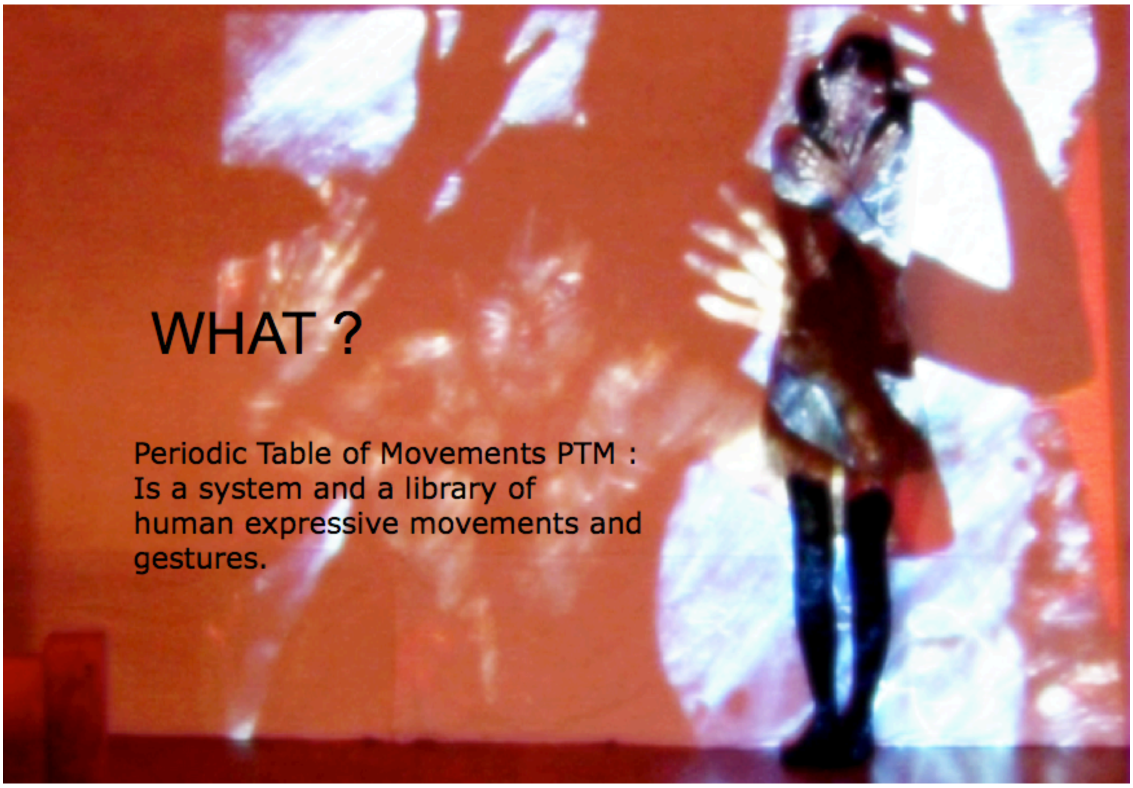

Figure 1.2 "What?" Extract from PP presentation and performance "Avatar", Hrynczenko, 2010a.

Figure 1.3 "Why?" Extract from PP presentation and performance "Avatar", Hrynczenko, 2010a.

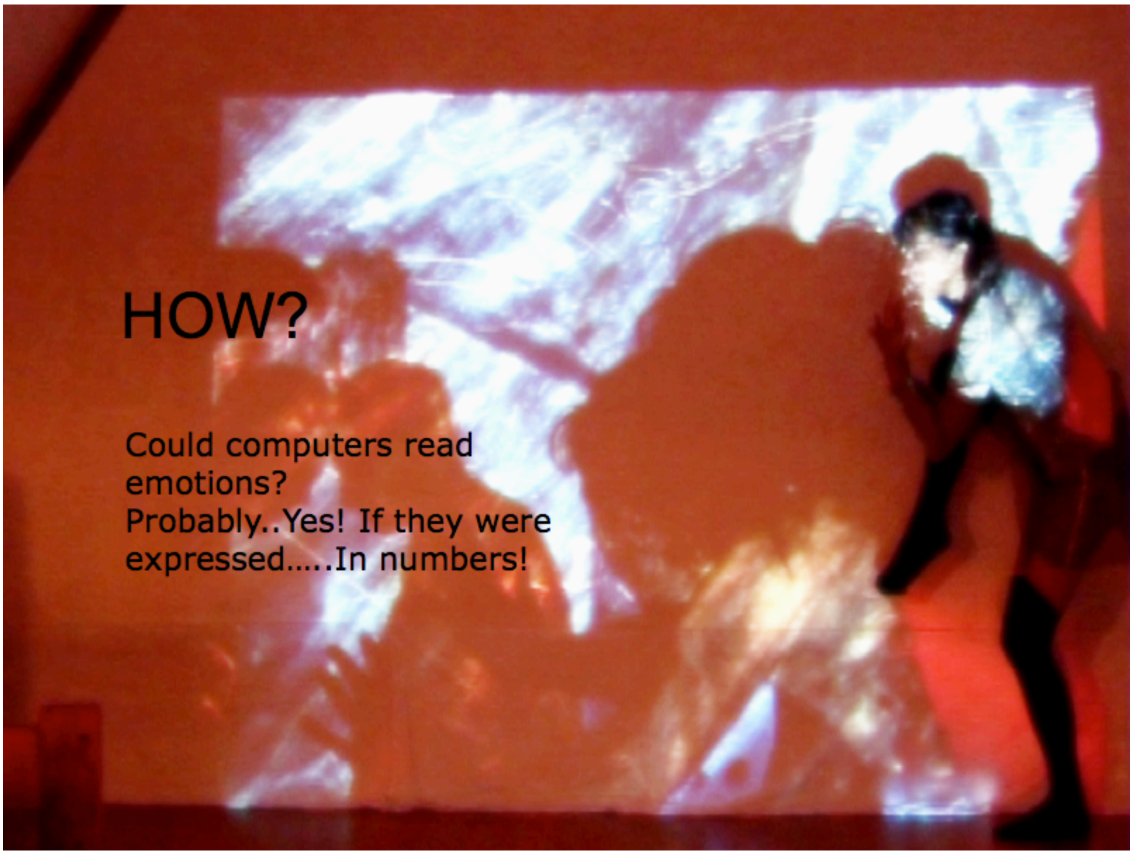

Figure 1.4 "How?" Extract from PP presentation and performance "Avatar ", Hrynczenko, 2010a.

Figure 1.5 "Why Not?" Extract from PP presentation and performance "Avatar", Hrynczenko, 2010a.

Since we tend to spend more time in digital environments than we did in the past, the question raised was; is this increasing or decreasing the human ability to have empathetic reactions?

During the performance preparations, the narrative content, a visionary idea, developed into concrete technical and philosophical questions; consequently, the idea of a database collecting human corporeal movement was born.

Figure 1.6 Vanguard: Saga of Heroes, Sigil Games, 2007 and *Toki*, Sankai Juku, 2005.

Since 2003, I have worked in parallel as a lecturer in animation and digital design at the Game Department at Gotland University (Sweden). While working with students on character design I recognised a need for new documentation methods for whole body movement focusing on emotions, i.e. expressive movement and gesture. The on-going trend in the production of game graphics largely neglects emotional expressions in favour of the meticulous design of characters' outfits (figure 1.6 left). From my perspective of performer and artist, these character designs contrasted with my perception of the human body—these stylised human replicas were lacking all emotional expressions. What if the game characters could use expressions of Butoh dancers? (figure 1.6 right).

I envisaged the documentation, a database of physically expressed emotions, as a helpful tool for my students. These students were 3D animators, often having only technical backgrounds but their lack of experience and a relevant reference framework resulted in poor or *uncanny* animations. Drawing from the references often used in 3D computer animation, the Uncanny Valley Theory (Mori, 1970) argues that when human imitations (3D avatars or robots) look and act almost human - yet not perfectly - human observers often react with disgust, aversion or even fear. The concept of uncanny is based on the German: *heimlich* and *unheimlich* (homely/canny; *unhomely*/uncanny), introduced by Freud (1919, p. 200) in psycho-analytics, and highlights '... the class of frightening things that leads us back to what is known and familiar.'

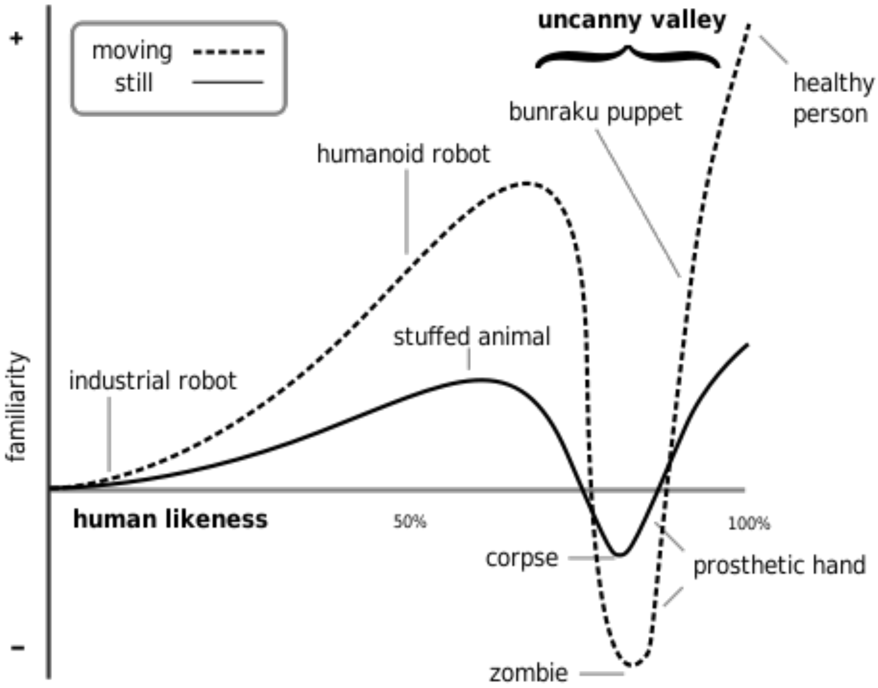

Figure 1.7 The Uncanny Valley. Mori, 1970, p. 33.

According to Mori's Uncanny Valley theory (Mori, 1970), body movement especially increases the emotional response in the observer as illustrated in figure 1.7 where the dotted curve illustrates movement's Uncany Valley.

Following this theory, there exists a strong connection between our empathetic reactions and the physiological and behavioural appearance of other humans, robots or animations thanks to the aesthetic models defined by comparative models we inherited either through culture or through genetics. Neuroscientific discoveries of *mirror neurons* in the ventral premotor cortex of the monkey by Giacomo Rizzolatti and collaborators in 1992 (Rizzolatti and Fabbri-Destro, 2010) also highlights the correlation between movement, a Motor Neuron which also happens to be a Mirror Neuron. Perception of movement correlates with empathy, a circumstance defined as a kinaesthetic empathy (Keysers, 2010). This phenomenon appears, for example, when spectators perceive the movement of an actor or dancer and experience that they themselves are participating in the movements they observe. This results in specific kinaesthetic sensations generating emotions connected to those movements, a kind of 'inner movement' as part of the experience, broadly described as, the “action observation network” (AON). These phenomena were previously presented in Lipps’ (1903) theory of 'Einfühlung'.

Lipps was also widely discussed during a conference I participated in: Kinesthetic Empathy: Concepts and Contexts (22 and 23 April 2010) organised by the Watching Dance Research Project, which explored the issue of kinaesthetic empathy in relation to dance and body-centred knowledge. The conference strengthened my conception of an existing, emerging problem related to the body and how we use new technology, and provided scientific information and relevant discussions between the dance/ performance art community and the representatives of science. The results of the research initiated by the Watching Dance Research Project are published in the book; *Kinesthetic Empathy in Creative and Cultural Practices* (Reynolds, *et al*., 2012).

In conclusion, human actions, both observed and embodied, should be considered when developing content and interaction models within the digital environment.
Following this line of thought, I realised that movement-based gaming content is not well represented in current games production.

The idea of the Periodic Table of Movement (PTM) as a database combined with a visualised emotive postures correlation table, stems from a need for spontaneous interactions with computers via physical movement. What if games were tools used also to enhance human kinaesthetic presence by augmenting their perception? When I expand this idea, I conceive the body as an interface that via embodied expressions interacts not only with the game content, but also via movement data, collaborates with a game system by generating new characters and narratives providing its own feedback mechanism.

When developing these concepts I was reconstructing ideas of contributors to dance and performance art development and forgotten pathways to invent alternative methods: Could the past century's knowledge, derived from pioneering performance and theatre work by Stanislavsky (1863-1938), Gurdjieff (1866-1949), Meyerhold (1874-1940), Schlemmer (1888-1943), Lecoq (1921-1999) and Grotowski (1933-1999) be transferred into the new interfaces and different game designs?

Many names could be added here in terms of choreography such as; Martha Graham (1894 –1991), dance and body-centred knowledge, movement analysis; Rudolf von Laban (1879-1958) and Eurhythmics technique; Emile Jaques-Dalcroze (1865-1950). In addition, the experience and knowledge of the last twenty years cultivated by cross-media; dance-media-technology and visual performance art scene. However, I realised, '…that this question may not be answered through analysis of why the Cartesian view of the human body dominates the gaming world, but rather via knowledge exchange among different art cultures through collaborative interdisciplinary practices beginning at an educational level'. (Hrynczenko *et al.,* 2010, p. 3) Consequently, I started to collaborate with the DAMA interdisciplinary network founded by the *Nordplus Program* for knowledge exchange among universities in the northern part of Europe.

Working with DAMA, which organises short and long-term thematic project based workshops, I recognised a need for visual pedagogical tools to bridge the knowledge between the different cultures (media art/gamers versus performance art/dancers). Searching for new approaches and insights across these disciplines, I started to produce small visual and interactive tools/artefacts to help with corporeal movement explorations, meanwhile looking for digitally transportable aesthetic values of human body movements. As a consequence of this related project, and in order to explore different methods of movement documentation, I participated in Mediamatic's workshop organised by Mediamatic for the Dance Film @ Cinedans festival in 2008. As a result, an interactive dance-video: *In Motion* (Hrynczenko, 2008), a revision of an interactive film I made using Director software in 2000, was produced. This was an old idea that was set in motion thanks to the possibility of a relational narrative system where data was collected and explored through the Korsakow System (Thalhofer, 2007).

The Korsakow System is open source software that allows users to produce nonlinear, database-driven narratives. A database of movements was an idea that crystallised from experiencing this type of software, emphasising the need for further development. With the idea of the Periodic Table of Movements, I applied for a place on the Masters Program in Screendance at the Jordanstone College of Art and Design (DJCAD), University of Dundee, Scotland, U.K.

The first iteration of the Periodic Table of Movements was based on a concept for a database system containing and combining representations of the various types of human emotional responses based in physical movements and the performance art techniques of Meyerhold (1874 - 1940), Grotowski (1933 - 1999) and *Butoh*. The aim was to create a multipurpose foundation for real-time responsive human avatar interactions, expressions, and patterns, which could be added to continuously.

The first period involved the investigation of possible models of emotions defined by psychology, and the formulation and testing of a basic set of archetypical, emotion-driven movement patterns. I considered the time and resources required for completing the application of the project and realised it exceeded the scope of my Master's studies. I therefore decided to structure my efforts as an iterative process, where the project would develop from an abstract research and design phase, through to developmental and application stages. Instead, the research focused on motion mapping based on several experiments that conclude in the application *Shadow Dance* (Hrynczenko, 2009a) presented as a site-specific installation at the Visual Research Centre/ Dundee Contemporary Arts (DCA), Dundee, Scotland, U.K in 2009. The application was based on audience interactions with motion-captured bodily movements projected on a screen, built in the open source programming language Pure Data (Puckette, 1996), and presented in real-time as time-based movement compiled to layers then exported as a photograph to a web based gallery (Hrynczenko, *et al*., 2010). I used *Shadow Dance* as a tool during my PhD research, when experimenting with creative movement, as well as a pedagogical tool during my DAMA workshops. This work is described in the paper: *Shadow Dance: installation and discussion on proposed solutions for embodied games through cross-disciplinary workshops within an educational context* (Hrynczenko, *et al*., 2010) presented to the DRHA 2010 Conference: Digital Resources for the Humanities and Arts (Appendix A).

Thanks to the support from the Arts and Humanities Research Council (AHRC) UK in the form of a doctoral award, the PTM database idea continued to develop in the second iteration during my doctoral studies at Duncan of Jordanstone College of Art & Design, (DJCAD) at the University of Dundee, Scotland, U.K.

In the second iteration, my investigations were focused on movement capture technology in order to find the best solution for the use of a video camera as the sole interface. The purpose here was to develop a realistic foundation for PTM. However, as an effect of Microsoft's release of the motion sensing interface, Kinect (Microsoft, 2010), in November 2010, I decided to work only with the development of the database, and documentation of emotive movements of human bodies. I have directed my focus on practical work within the studio with performance art students and on the validation of the video material i.e. emotions contained as silhouettes in motion.

Thanks to feedback from the gaming and computer science communities during a research symposium at Gotland University (2010), I decided to focus only on the elements of movement based on emotions, excluding the elements that built on performance art techniques. This change allowed a focus on analysis of the forces that produced the movements as basic elements, following this metaphor of the Periodic Table of Elements (Mendeleev, 1869–1905). Inspired by different possibilities that data visualisation could provide, transformation of the previous idea was developed.

Consequently, the Periodic Table of Movements (PTM) database became an attempt to describe human emotions through both qualitative and quantitative data. Whereas in the first case, this used only kinematic data such as the measurements of the quantity of motion and the x, y coordinates of documented movements. In the second case, these parameters became the foundation for triangulation, based on the interpretation of emotional expressions and grounded in methods used in ethnographic research and those used in art for data visualisation.
In both cases, my intention was to amplify the visual qualities of human embodied expressions. This emphasised the provocative meaning that the name Periodic Table of Movements mediates. Despite the controversy of this parallel meaning, my goal was to find a convergence between art and science in my working process where scientific methods were used preferably as artistic tools.

1.4 Aims, Objectives and Audience

The research, ontological in its character, through movement and gesture analysis and togethere with the mapping of body language via data visualisations, aims to provide a database and a collection of digital assets by emphasising properties of bodily expressed emotion as visual concepts. These properties are analysed in terms of shape, space, volume, intensity, time, expressions communicative qualities and similarities and dissimilarities. The properties are also analysed in the context of character development for games and expression readability for optical, motion sensing input devices. In line with the phenomenological approach, the intention of this part of the research is to provide a pedagogical toolset and framework for movement analysis. This framework could help students in game design and graphics to immerse themselves in and reflect upon human kinaesthetic and visual experiences by interacting with it through their visual perception and their bodies.

The visualisations of four emotions: anger, fear, joy and sadness are intended as data samples and targeted for educational purposes as a source for experimentation and learning. However, the visual assets can be also used in a broader context for students, educators, artists and researchers from various knowledge fields as a framework to elaborate on and reason about the meaning of expressive gesture. The longstanding aim, based on the results of the PTM database is to create a multiplicity of visual interpretations of human emotion through an interdisciplinary approach. In addition, by highlighting the kinaesthetic values of emotion, my aim of this approach is to create a laboratory environment that can contribute to the development of interactive applications and games, based on optical, motion sensing technology.

For the theoretical part of the research, partly represented in the contextual review, the principal objective is to elaborate on and discuss the body in relation to interface design and virtual representations of expressive gesture and movements. Therefore, the emphasis in this part is focussed on concepts of emotion, presence, visual perception, perceptual interfaces, movement recognition and data visualisation. The aim of this approach is to highlight existing knowledge about human body expressiveness that already exists and is widely explored in Performance Art and in the field of Dance and Technology (a field of modern dance). In this context, the contextual review both underpins the practice-based research in terms of the correlations and influences in the study, as well as collecting examples of art, science, dance and performance art that could be useful in game design and graphics education.

From a methodological point of view, the aim of this research is to explore the phenomenon of human expression through scientific and artistic means where each key element of the research is discussed both from a subjective and objective perspective in relation to its own purpose and as an aspect of the completed project.
The objectives of the research are to apply a hermeneutical approach to artistic development using Heuristic guides originating in phenomenology. This is achieved mainly by using an iterative model during the discourse and the empirical stages of the research by the iteration of four existential concepts: (spatiality), lived body (corporeality), lived time (temporality) and lived human relation (relationality or communality) (Van Manen, 1990, p. 10). Through this approach, the validity of the visual assets of emotion is explored in the context of visual artefacts as epistemic objects trough two combined methods. One, that maps artists thoughts during the work process, and the second, in the form of qualitative and quantitative methods for the presentation of research results based on approaches used in the anthropology of dance, biology and statistics.

1.4.1 Target Audience

The main output of this study, a virtual space for exploration, is an online database containing multiple visualisations of human embodied expressions of four specific emotions: anger, fear, joy and sadness. However, the thesis analyses and discusses emotion from the perspective of its ontological entities and through both dance and performance art perspectives. This study primarily addresses students and educators of game design and graphics by providing tools for the discussion, learning and exploration of embodied emotion. In the context of the expressiveness of the human body, the framework provided aims to extend the perspective of both the game content and associated technical development. The structure of the database provides an opportunity for the material to be used, reused and explored in future studies and research across different fields of knowledge. The study provides analytical tools and facilitates discussion on the human body as interface in the context of optical, motion sensing input devices and real-time data aquisition. This resaerch would also be beneficial for students and educators in the field of human-computer interaction, dance and performance art.

Within an educational context, the PTM database provides students, educators and researchers content that is open to subjective interpretation and manipulation. By representing emotion from various perspectives it provides a multimodal approach to research and learning. In parallel to the practice-based content, this thesis discusses the human body in the context of expanding digital worlds from a multi-layered, interdisciplinary perspective. The research proposes a broader forum for the discussion of embodied emotion in the context of its pedagogical, historical and socio-cultural aspects. The thesis discusses and elaborates on the methodological issues in terms of both a subjective and objective approach to research from the perspective of an artist and researcher. This is undertaken by exploring the value of visual artefacts as presentation and representation of qualitative and quantitative data, and by the holistic approach to research and learning grounded in heuristic guides originating in phenomenology. This research should therefore appeal to, and have relevance for, the wider scientific and arts based communities.

1.5 Known Issues and Limitations

The focus of this thesis is not on games, game design or even game graphics per se. Instead, the study focuses primarily on the visual qualities of emotional expressions of emotions such anger, fear, joy and sadness in the context of character development for games and expression readability, utilising optical, motion sensing input devices. This is mainly explored and documented in the framework of an online database as assets useful for character design and game design.

In relation to the search for the universality of expressions, the decision to use four basic emotions: anger, fear, joy and sadness as a basis for the database are centered on Fridlund’s, Ekman’s and Oster's (1987) literature and research on facial expressions and Plutchik's (1980) *Psychoevolutionary Theory of Basic Emotions* who's findings reveal the universality of these four emotions. However, the visualisations of emotions offered, together with the recorded expressions are not presented in the database as universal, the universality refers only to the choice of these four emotions.

In terms of movement characteristics, the large number of movements investigated is combined with elementary movements that could be categorised. Although, several of the emotive expressions are unique they are dependent on the personalities of the individual expressing them. Therefore, it is not possible to design definitive movement patterns that describe each of the four emotions due to the small sample of emotive expressions that this research was based on. In conclusion, the PTM database provides indications of how these emotions are often expressed via physical movement and gesture.

Other possible issues relate to the visual material on which the practice-based research is grounded. The study is intentionally based on exaggerated emotive representations of whole-body movements presented as silhouettes. The first phase of the project, an emotive whole-body movement video collection, is based on participants performing an interpretation of particular emotions, not emotions as they might be experienced. The reasons for this are two-fold. The expressions in this study are analysed from an ontological perspective looking mainly for the visual qualities of expressed emotion in which the variety of expressions is the object of the research and not the participants' performance experience. Secondly, the participants' different experiences in performative actions contributed to the subsequent emotion recognition process based on an online survey by exemplifying differences in the communicative qualities of emotions, for each of the video clips collected. Consequently, a scale of expression readability could be provided for the database, as an indicator of gesture expressiveness. This feature is used to search and compare different scales of the expressiveness of emotion, which potentially provides a useful tool for character animation.

Another limiting factor concerned the data collected during the online survey. The online evaluation was focused on the emotion recognition of silhouettes in motion stored in the database, which provided an indicator of the communicative qualities of expressions for each of video clip. However, other standard response parameters were collected such as: occupation, gender, age and their geographic region. Based on the small sample group of 25 participants and unequal data distribution, this data is only used in terms of statistical analysis as a basis for exploration of data visualisation techniques.

Other factors relate to data collection as a basis for explorations of visualisation techniques and in particular the assessment of colour recognition according to eight emotions (section 5.2.3 *Colours and Emotions Survey Experiment*). In this study, participants categorized perceived emotions based on Plutchik's metaphoric classification of emotions as colours. The participants only represented Nordic countries from a narrow geographic sample range. However, this data was only used as a sample for explorations of quantitative data as a case study of methods for data analysis and visualisation.

The visual assets collected in the PTM database are not to be regarded as a definitive answer of how emotions are usually expressed, rather as an exploration of possible visual qualities of each of the four emotions, where methods for the visualisation of emotions are explored as a development of a larger collection. The intention is to expand the database both in terms of amount of assets available as well as the number of emotions available for analysis and interpretation.

1.6 Summary

The development of more sophisticated sensing and input technologies and the growing number of inhabitants of virtual worlds and online games, highlights the need for a better dialogue between our physical bodies and their relationship to digital space. When taking this scenario into consideration, the necessity to produce a platform for more research into bodily expressions resulted in the idea of a database that could work both as an archive and experimentation platform in an educational and research context. The database provides a visual representation of emotion by focusing on the visual qualities of embodied emotion such as shape, space, volume, time, intensity and the communicative qualities of expressions. This approach serves a dual purpose for game character creation e.g. narrative development and as the reference object for optical, motion sensing devices. Additionally it acts as a solid foundation by underpinning game *Mechanics, Dynamics and Aesthetics (MDA).*

The need to archive whole-body emotive-expressions as a future elaborative platform for education and research emphasises the research subject and several consequential sub-questions; how can emotions expressed via the whole-body movement be visually documented and archived as a reference framework to stimulate the use and studies of expressive gesture in digital environments?

From the perspective of cognition and learning processes, visual input has an important role in how we remember and retrieve information, how we learn and store knowledge in the memory, and how we use this knowledge in socio-cultural contexts.
To understand these issues, the contextual review emphasised different perspectives on human expression and the position of the human body in relation to technology. In particular, the contextual review showcases emotion from multiple perspectives, embodied expression across the timeline of technological development and provides cases of applications in contemporary media and performance art. In short, showcasing existing knowledge in media and performance art that is applicable to game art and design. This part of the study is an investigation that underpins the practice-based research by connecting existing knowledge to each stage of the study. Whereas, the practice-based study consisting of the PTM database with associated artefacts, aims to provide elaborative tools for exploration of human body movement and gesture within the scope of four emotional expressions: anger, fear, joy and sadness. The structure of the database provides an opportunity where the material can be used, reused and explored in studies and research in the field of game design and graphics. However, the database as a tool for research is beneficial to different fields of knowledge. The study contributes with analytical tools and discussion on the human body as interface in a context of optical and sensing devices, which may be also beneficial for students and educators in the field of human-computer interaction, dance and performance art.

The methodological approach, explained in the next chapter, is based on a phenomenology of embodiment introduced by Husserl, linked to the notion of kinaesthetic consciousness as explained by Merleau-Ponty (1962), and contextualised by Van Manen, (1990) in terms of four “existentials”: *spatiality*, *corporeality*, *temporality* and *relationality* (Van Manen, 1990, p. 101). My aim by taking this approach is to apply this strategy to human interaction with digital content, where the body is considered holistically as an integral part of digital content development. By mapping body language through movement analysis and data visualisation, the database provides useful visual digital assets based on an ontology of bodily expressed emotion. Consequently, the visual properties of emotion are analysed in terms of shape, space, volume, intensity, time, expressions, communicative qualities and differences.

2 Strategy

> *I do not avoid objectivity nor seek subjectivity, but try to find an equivalent for whatever is the effect of my relation to a thing, or to a part of a thing, or to an afterthought of it. I am seeking to attune my art to what I feel to be the keynote of an experience. (Walkowitz, 1913, p. 2)*

2.1 Methodology

Overall, multiple and hybrid research methods were used across the different stages of the practice-based investigation (Brever and Hunter, 1989) folded in and generated by action, cognition and perception. This construction, grounded in an iterative process, has empowered the triangulation where received qualitative and quantitative data has been cross-referenced (Gray and Malins, 2004). Therefore, considering the varied methods used, the term multi-method approach is used as the generic term for the research methodology.

This multi-method approach represents a naturalistic approach in real world situations that refers to the fields of art where visual and performative practice is taking place. These real world situations require research methods based on case studies, where words, pictures, and reflective narratives must be taken into account in order to add meaning to quantitative data. The pragmatic setup of the methodology enables the possibility of mixing and matching contextual and situational factors as they relate to the phenomenon of interest. During the research, both qualitative and quantitative methods were applied. Consequently, cross-disciplinary configurations in relation to the various stages of research were chosen, which is typical for the selected multi-method methodology.

The quantitative research methods are based on empirical investigation of emotions expressed as corporeal movement, where differences and similarities in movement recognition were examined via computational and statistical techniques during the phase of movement analysis and data visualisation.

The measurements were based on the statistical data gathered from an online survey and the recorded expressive movement measured according to several parameters described in section 2.2 *Research Design*.

The qualitative study, exploratory and interpretative in its nature, is based on techniques which seek to describe, decode and translate participants emotions according to their instructions, as well as on ocular evaluation of visual data initially introduced in Silhougraphs® (Kealiinohomoku, 1989), a method borrowed from the anthropological study of dance. In this section, movement characteristics for each emotion were explored based on an immersive experience. The iterative process was broken down into different elements that have required a variety of methodologies, as listed below, with associated specification of how these have been applied.

Multi-method methodology includes:

1) A Hermeneutical approach to artistic development,
   - Phenomenological inquiry
   - Heuristic guides
   Applied during the research and writing process

2) Heterophenomenology
   Applied during documentation, analysis and thesis writing

3) Triangulation,
   - Cross referencing of qualitative and quantitative results
   - Evaluation
   Applied during the evaluation process and movement analysis

4) Artist research in action /Participatory Action Research (PAR)
   Applied during DAMA network workshops

5) Anthropological study of dance
   - Cognitive science: Silhougraphs®
   Applied during analysis of data

6) Exploratory data analysis (EDA)
   - Statistics: explanatory use of data for visualisations

7) Data visualisation
   - Visual communication: creation of charts and diagrams

2.1.1 Hermeneutical Approach to Artistic Development

The artistic practice used in the research could be described as a hermeneutical approach to artistic development, which consequently mirrored the holistic ideas of phenomenology in an iterative model using both qualitative and quantitative methods and artistic means. The hermeneutical approach to artistic development methodology is continuously investigating and discussing in an iterative manner each key element of the research in relation to its own purpose and as an aspect of the completed project. According to Van Manen (2003) phenomenology is a philosophy experienced from the first-person viewpoint with the focus on the personal, and the individual approach to the world. This research is explorative, interpretational and conducted on the basis of my experience as artist, dancer, performer and animator.

Hermeneutics is the theory of interpretation and understanding of linguistic expressions mainly derived from texts. Nevertheless, modern hermeneutics, includes all verbal and nonverbal communication as objects of interpretation encompassing other disciplines such as social sciences, law, psychology or architecture (Arjoranta and Karhulahti, 2014). In modern philosophy, and in the context of phenomenology, as presented by Heidegger (via Dreyfus, 1991, p. 34), hermeneutic phenomenology '…is an interpretation of human beings as essentially self-interpreting'. Interpretive phenomenology, as defined by Merleau-Ponty (1962), approaches the word from an inter-subjective perspective in which the body exists in relation to time and space, and in relation to other bodies. Merleau-Ponty contextualises the nature of the inter-subjective as "being-to-the-world".

Van Manen (1990, p. 101) follows Merleau-Ponty's ideas and describes the four existential concepts as interconnected with each other: i.e. the body relates to the "lived other" (relationality) shared with others in interpersonal space or lived "felt space" (spatiality), as well as existence being related to 'lived time'.
In this context the interpretational model allows the extension of the corporeal experience in an investigation that encompasses the four existential concepts; a Heuristic guide of Phenomenology (figure 2.1).

Figure 2.1 Four existentials; a Heuristic guide of Phenomenology, adopted fromVan Manen, Hrynczenko, 2014.

> All phenomenological human science research efforts are really explorations into the structures of the human lifeworld, the lived world as experienced in everyday situations and relations. Four fundamental lifeworld themes (or existentials) may be helpful heuristic guides for reflecting on human experiences: lived space (spatiality), lived body (corporeality), lived time (temporality) and lived human relation (relationality or communality) (Van Manen, 1990, p. 101).

These four existential concepts are guides for interpretation and reflection during the research process and are addressed frequently during the different stages of the project. Van Manen has formulated an outline for hermeneutic phenomenological research, which encompasses a conceptual methodological framework based on six research activities that dynamically interlace with each other.

> (1) turning to a phenomenon which seriously interests us and commits us to the world;
> (2) investigating experience as we live it rather than as we conceptualize it;
> (3) reflecting on the essential themes which characterize the phenomenon;
> (4) describing the phenomenon through the art of writing and rewriting;
> (5) maintaining a strong and oriented pedagogical relation to the phenomenon;
> (6) balancing the research context by considering parts and whole
> (Van Manen, 1990, pp. 30-31).

2.1.2 Heterophenomenology

Kozel's (2007) interpretations of Dennett's (1991, 2003) heterophenomenology, particularly in relation to dance, performance art and technology, have contributed to a method used during my work with students. Heterophenomenology, a term coined by Dennett in the context of methods used during a scientific investigation, as he explains, refers to 'phenomenology *of another* not oneself' (italics in orginal, Dennett, 2003, p. 19); a third-person view. Heterophenomenology in relation to performance art refers to the possibility of reconstructing another person's experience. These ideas are reflected in the documentation process as well as in the analysis of the documented material, working and interacting in parallel with the ethnographical studies of dance.

> The phenomenological experience of another person unfolds across physical description with latent conceptual elements extrapolated and can be relevant to me based on my having experienced the same thing, or simply because I have the ability to construct meaning empathetically, perhaps through imagination or previous experience. Quite simply, I can resonate with another's experience (Kozel, 2007, p. 25).

The concept of 'heterophenomenology' has implications for the analyses of expressive movement documentation, explaining the dual role of the researcher. In the description of Kozel's (2007) interpretation of 'heterophenomenology' she gains support from Merleau-Ponty: 'Other people are not "fictions with which I might populate my desert"; instead, they are "my twins or the flesh of my flesh" (Merleau-Ponty via Kozel, 2007, p. 59). With Merleau-Ponty's reflections in mind, Kozel points out that in her version of heterophenomenology the researcher is not detached from the observed participant but he/she 'relies upon shared experience' (Kozel, 2007 p. 59). During the workshops and documentation process, interpretations were provided for the future analysis of movement in data visualisations. Heterophenomenology was applied to this study, where the investigation takes the form of practice-led, qualitative research.

This is a different approach that combines several perspectives on the body including the subjective body, in this case, the experience of my own bodily memories connected with the subjective experience of the subject of the study. This approach was selected simply because the documentation of the emotional experience would be not possible if I excluded my own or the participants' physical experience that builds on these very subjective and personal corporeal memories.

2.1.3 Participatory Action Research (PAR)

Participatory Action Research is a suitable description to apply to this form of research as a complementary approach. This is evident, especially in relation to the workshops, where the creative process was taking place, forming the basis of each participant's performance of eight emotions, each of 30 seconds duration.

These preparatory non-verbal physical actions have grown from the co-operative knowledge base, forming the corporeal memory that enables physical interpretations of emotion by the participants.

The PAR methodology is similar to the Hermeneutical approach, in that it is an iterative process, however, the structure is different. In PAR the focus is on the group, whereby all participants, including the researcher, examine the actions together. PAR has roots in social psychology, however, it is applicable to artistic research, especially in collaborative situations when all participants are generating data together to produce relevant knowledge that results in action (Greenwood and Levin, 1998).
The DAMA workshops were developed during the current research on the basis of this methodology by creating a platform for active implementation of ideas and their further development in directions beyond the current research objectives. Furthermore, the workshops have provided different perspectives for further development and collaborative evaluation of models, tools and techniques evolving from creation of the database.

2.1.4 Silhougraphs®

Silhougraphs®, a name coined by Kealiinohomoku (1989, 2008), is a method, founded on ethnographical studies of dance, developed by Kealiinohomoku in 1989 and used as a complementary method to Labanotation and Benesh dance notation (Hutchinson, 1954; Benesh and Benesh, 1956). Kealiinohomoku (1989, 2008) used Silhougraphs® as diagnostic tool for individual dancers during dance training. She describes the method as aiming to: '…focus the visual attention of those primarily trained to listen to look at dancer shapes and not be distracted by non-space-shaping features such as colours of costumes or facial expressions.' (Kealiinohomoku, 1989, unpaged)
Silhougraphs® are graphic representations of movement in action used by

Kealiinohomoku as classifiers for dancers shapes in space, their costumes, and paraphernalia by epitomising their movements and postures.
In terms of cognitive science, Kealiinohomoku's Silhougraphs® provide evidence that humans have the ability to extract complicated information from two-dimensional shapes. This is, as she states, an ability that humans developed during evolution that is connected to an early mammalian visual cortex. In the description of these functions, Kealiinohomoku refers to previous research on the holographic paradigm of the human brain (Duncan and Kealiinohomoku, 1996).

In the context of this study, the Silhougraphs® method was applied during the documentation and evaluation process as a classification method of emotive expressions, providing a rationale and framework for the use of silhouettes. The same method was used when analysing human bodies in motion and particularly during the triangulation process that bycome the next iteration of posture analysis and the final classification of postures. In practice, Silhougraphs® methods were embedded during the visual analyses of movement data, which resulted in visualisations of movement sequences as key frames of silhouettes. During this step, particular postures were highlighted in order to visualise characteristic similarities and differences between the expressions of anger, fear, joy and sadness. The documentation process is detailed in Chapter 4 *Art As Vehicle, Research in Practice* whereas the triangulation method is described in section 5.2.4.10 *Triangulation, Quantitative Analysis of Visual Data.*

2.1.5 Triangulation

Different fields of knowledge use triangulation methods for different purposes, and in different ways. For example, in social science the main purpose is for the validation of data through cross verification from two or more sources. The aim of triangulation, as applied in trigonometry, geometry and cartography is to find the location of a single point by measuring angles and sides formed from two known reference points.
The purpose of triangulation in ethnographic research is to enhance the comprehensiveness of data by the use of two or more equivalent processes. Additionally it is used to contextualise the interpreted material and to explore the data diversity in terms of similar and dissimilar viewpoints. (Rock, 2001).

During the research, I use the triangulation method in two different stages of the study.

In the first case, the main aim was to ensure that the expressions of silhouettes in motion were readable for each of four emotions. Applying the triangulation method as used in ethnography, 25 viewpoints (number of survey respondents) were used in order to estimate if the expressions of silhouettes were recognised according to the four emotions being tested. The recognition data was collected and compared according to the emotion recognition answers of the participants and based on a recognition factor scale of zero to five points. Finally, the data was visualised taking into account the viewpoints of the differences and similarities of the readability of the expressed emotions' silhouettes. The purpose of this approach was to visualise the communicative qualities of the expressions contained in each of the video clips and for each actor.

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In the second stage, the triangulation process was based on several subsequent stages and grounded in the quantitative, qualitative and visual data collected. This data was used for comparisons and this process continued in an iterative manner and through several stages. In the first phase of this second stage, the analysis of emotive whole-body expressions proceeded using quantitative research methods. This was conducted by the analysis of qualitative data and statistics based on expressive movement measurements taken via VideoAnalysis software developed by Jensenius (2007-2012). The software provided non-real-time video analysis of quantitative features of movement contained in the video files, producing quantitative data in form of a "txt" data file. To find patterns of similarities and differences among emotional bodily expressions, this quantitative data was converted into data visualisations. In the second phase, the aim was to find characteristic silhouette postures for each of the four emotions that could work with optical, movement sensing devices. For this purpose I highlighted relevant postures in the chronophotographic charts, contextualising these in terms of movement sequences and time. The method used in this process was visual and based on silhouette shapes and expressions, a method borrowed from dance anthropology.

Finally, all the methods previously described were used to build the foundations of the triangulation method, visualisation and infographics. For this purpose, statistical concepts underpin the generalisation of the research results, which was necessary to obtain the data visualisation. However, the source data on which the visualisations are based is quantitative, yet general, in its nature. The qualitative research methods used were based on the empirical investigation of emotions expressed as corporeal movement, where differences and similarities were examined via a visual triangulation model, undertaken during the data categorisation and evaluation phase of the movement data. The visualisation process adapted tools and methods that originate in cognitive and natural science. The measurements were based on both the visualisation of statistical data gathered from questionnaires, and the recorded expressive movement data together with the analysis of silhouettes according to the Silhougraphs® method. The visualisation of movement data provided the possibility to analyse correlations and differences among expressions of the four emotions: anger, fear, joy and sadness.

In the course of this investigation, I have adopted existing triangulation methods borrowed from ethnographic research and the anthropology of dance (Silhougraphs®), which uses the visual analysis of human silhouettes.
The process involved both the use of quantitative and visual data, in which the final results were based on my own visual interpretations. In this case, my judgement about the similarities between the postures under investigation relied on my visual sensibilities as a performance artist and animator. During this process, I was crossing boundaries incorporating scientific, embodied, and visual methodologies that resulted in a chart (figure 4.39) that also became an epistemic object representing the cummulation of this process.

2.1.6 Exploratory Data Analysis and Data Visualisation

Exploratory data analysis (EDA) is a strategy used in statistics to analyse data sets where visual methods are used to summarise the main characteristics of complex data sets. This was an approach I used in the study of data collected from the online survey. This was mainly, used as an explanatory investigation in data aesthetics and to present the correlation between the video clips under investigation and their related expressions communicative qualities by the use of emotion recognition points. Several data sets such as those described in section 5.2.3 *Colours and Emotions Survey Experiment* and 5.2.4.3 *Analysis According to Respondents Personal* Data were only used as a method for developing relevant statistical analysis knowledge.

Data Visualisation as a field of visual communication is used in this research to explore the aesthetics of quantified data in a schematic visual form and to provide complex information in an easily understandable format. Data visualisation is both a science and an art and it has been used here for the presentation of quantitative data as evidence where the graphical and aesthetic means converge as both the interface and an analytical tool. The main purpose of data visualisation is to provide information in the most efficient way as exemplified through this research and using accepted techniques:

- Scatter plots for the presentation of kinematic data received from the Video analysis such as x and y coordinates of movement and quantity of motion QM versus time,
- circular diagrams for comparison among communicative qualities of expressions,
- pie charts and bar charts for survey respondents' data.

2.2 Research Design

This research is designed in three sections related to the three years of doctoral study. During the first part, empirically based methods were applied in order to gather video material that is representative of expressive movement of eight emotions. Quantitative and qualitative methods were used as explanatory investigations of data visualisation techniques and analysis of the visual properties of basic sets of emotions. Additionally, a review of research and practice in the fields of science and art was undertaken to determine how this doctoral investigation correlates to past and existing bodies of work on performance art versus technology, game design and databases as tools for artistic expression.

The second element of the research acts as a validation of the first part. This portion of the project aims to ensure that the emotional presence or subtlety of movements is not lost in their interpretation and translation by the system. In this phase of the project, material based on four emotions was stored within the database and evaluated in terms of its communicative values through the online survey. The third part of the research investigates visual representations of four archetypal emotions via quantitative and qualitative data analysis. This material stored within the database was converted to quantitative data utilising the software program, VideoAnalysis (Jensenius, 2017-2012).

The results of the evaluation build the foundation for data visualisations and infographics as well as providing a strategy for future software based on contemporary technologies such as Kinect (Microsoft, 2010) as a movement input device. The results, a set of epistemic objects, are presented as a scaled down version in figure 2.2 and in detail in Appendix D *PTM System and Database Infographics; a Proposal for further* *development of the PTM database with movement sensing devices* in scale 1:2. The proposal is one of three additional outputs, the second is a *Cross-disciplinary Knowledge Map* (Appendix C) and the third; *X-ray of Emotional Kinesphere* is a result of further processing of the database content. All three are ancillary projects stemming from this doctoral study.

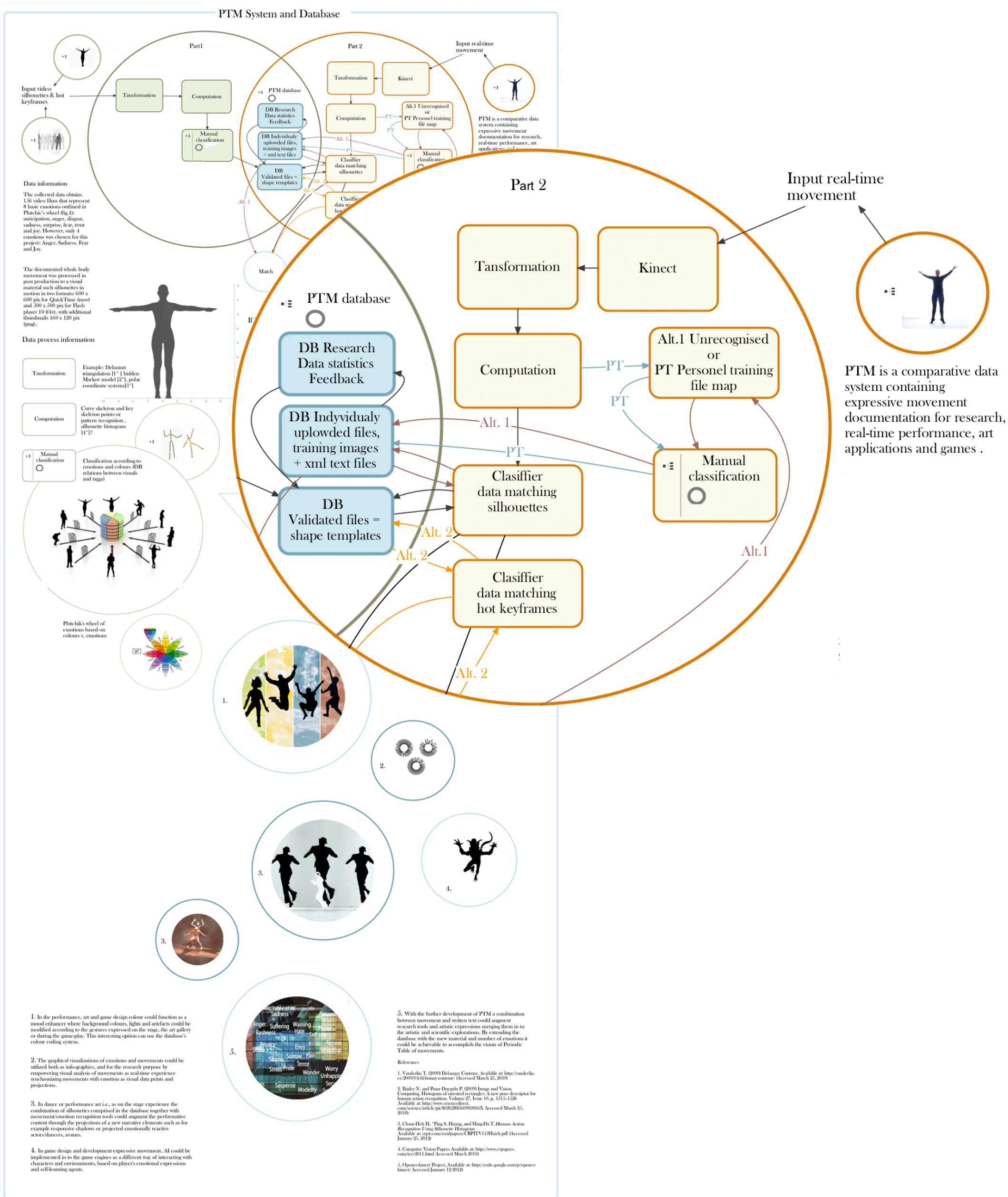

Figure 2.2 Proposal for further development of PTM database, Hrynczenko, 2013.

The research has been designed to integrate artistic inquiry with scientific models that are distributed across a timeline divided into three parts and illustrated in the document *Methods in The Context of The Timeline and Purpose* (Appendix B). In order to address the aims and objectives of the research, the following activities and methods were used as described in the following sections.

2.2.1 Part One

The first part of the research starts with the contextual study of human emotions and the database in art, which was a preparation for the design of the online database. During the first period of the research, the challenge was 'to map the terrain' (Gray and Malins, 2004), selecting suitable methods and to find focused areas for research. This journey is described in Chapter 3 *Contextual Research: A Journey in Three Parts* and is visualised in the *Cross-disciplinary Knowledge Map* where three areas are explored: Emotions, Movements, and Database. These represent the three main subjects of the doctoral study. The map was a helpful tool in simplifying the search for information and defining the specific keywords and relationships in cross-disciplinary areas, as well as mapping previous and on going research in these fields.

During the DAMA workshop in Tallinn, video material was collected in line with *Plutchik´s Wheel of Emotions* (see section 3.2.4), which represents the expressive movement of eight emotions; anger, anticipation, joy, trust, fear, surprise, sadness and disgust. The workshop on colours in relation to emotions was created in the form of a survey using a closed-end questionnaire and multiple-choice questions (Appendix F). The quantitative methods used were selected to gather the data for the exploration of data visualisation techniques. The idea of using colours as conceptual metaphoric descriptions of emotions have two important purposes. At one level, they are used to label visual material in the database together with the data visualisations. At another level, they use colours as visual feedback amplifiers of corporeal movement for future applications of the database with movement and other sensing devices.

In order to develop an overview of the movement analysis of archetypal gestures, a phenomenological point of view has been employed. Human movements have been classified into six different categories, based on conditions such as: 'corporeality, relationality, time and space' defined by Van Manen, (1990) as Heuristic guides grounded in Phenomenological inquiry. It is a holistic approach relying on bodily movement following the brain's development from the first days of infancy to the fully developed adult in relation to the meaning of movements and gesture. This is shown visually in the *Flowchart of human movement classes* (Appendix I) The study was used to provide the groundwork for the *Framework of action points* that became part of the pedagogical toolset used during the workshops and described in section 4.2.3 *Framework of Action Points.*

The objectives for the research during the first phase were:

1. To explore visualisation techniques by qualitative methods of inquiry, utilising Plutchik´s colour metaphoric schemes in relation to emotion perceived as colour.
2. To define classes of movement based on Heuristic guides, previous knowledge and workshops with dancers.
3. To define the *Framework of action points* in a pedagogical toolset that could be used during the workshops.
4. To gather video material representing emotive expressions that could be used as samples in the database design.

2.2.2 Part Two

In parallel to the contextual research a second iteration of video material was recorded in a specially built backlight studio in order to provide good technical preconditions for the conversion of the video material to silhouettes during the postproduction process. The video recordings took also place during the DAMA workshop in Visby, Sweden in a green-screen studio. As a result of all recording occasions, the data set collected included 156 video recordings representing eight basic emotions. Through the postproduction process the video material was converted to silhouettes in motion. In postproduction, only four emotions were used: anger, joy, fear and sadness. During the next phase, the 76 video clips were stored in the database and evaluated through an extensive online survey. The main purpose of the survey was to answer the question: To what extent do the silhouettes in motion communicate the emotional states of the performers?
However, taking into consideration the variable expressiveness and abilities of the actors, the question became simplified to: What communicative value does each of the video clips express?

The web-based survey was developed with the help of programmer (see section 2.2.6), to help answer the question. Four emotions: anger, fear, joy and sadness are represented in the form of silhouettes in motion in the questionnaire. The participants were required to name the emotion represented using a closed-ended questionnaire. This was acheived by using a menu of multiple-choice questions containing four basic emotions from Pluchnik´s Table of Emotions: anger, joy, fear and sadness and by scoring on a recognition difficulty scale from one to five. The aim of this approach was to explore the communicative value of the visual material presented as silhouettes in motion. The final output was analysed on the basis of the percentage of correct answers. The analysis of the data was conducted according to the methods used during the third section of the research described in section 2.2.3 *Part Three*.

The objectives for the research during the second phase were:

1. To investigate human emotions, expressive movement and databases through the contextual studies.
2. To gather video material representing the movement patterns of eight emotions as silhouettes in motion.
3. To build an online database for the questionnaire
4. To adapt the video material to online publication
5. To investigate the communicative value of silhouettes in motion in each video clip compared to the human perception of emotion through an online questionnaire in order to answer the question: What communicative value does each of video clips express?

2.2.3 Part Three

The third part of the research investigates the analysis of visual and quantitative data from the four archetypal emotions: anger, fear, joy and sadness. In this phase of the research, video material stored within the database was evaluated through the analysis of movement based on graphic and numerical data. The sequential visualisations of movement were produced utilising FinalCut Pro (Apple, 2001-2010) and Photoshop (Adobbe, 2010), where the quantitative data was created via VideoAnalysis (Jensenius, 2017-2012) software. In this process 76 data samples were produced that contained numerical information extracted from movement in each frame of the video. In the next step, the *Mean* of the data was calculated. This was derived by adding all the values of each associated category, and then dividing the sum by the number of items in each category. This resulted in a number signifying the average representation of movement for each emotion and movie clip in the database. The results of the evaluation contribute to the data visualisations and infographics presented in section 5.2.4.7 *Spatial and Visual Data Analysis*.

The objectives of the research during the third phase were:

1. To convert video frames to stills and integrate them into one sequential visualisation of movement.
2. To convert video material of expressive movements to quantitative data.
3. To convert quantitative data via statistical analysis to diagrams and data visualisations of movement.
4. To convert video frames to still image graphics in order to produce an overview of movement patterns.
5. To cross-reference the data collected with the previous research on cross-cultural similarities aligned to expressive gesture.
6. To build an online database of videos, graphics and numerical data that illustrates the visual properties of emotions, represented as whole body movement.
7. To provide a strategy for future software development based on the motion recognition capabilities of Kinect (Microsoft, 2010) and other motion sensing technologies.

2.2.4 Quantitative Research

During the research, three empirical studies based on quantitative methods were performed, each with a different purpose. The first one, focused on colours and emotions, and investigates the relationship between colours and emotions, based on Plutchik's *Colour Wheel of Emotions* (2001). The study, explorative in its nature was aimed at exploring data visualisation methods. The second investigates emotions as silhouettes; a study based on the online survey, *Expressive Movement Evaluation Survey* (see section 5.2.4), and is intended to investigate the readability of expressive movement used as reference material in the database. The study was based on silhouettes in motion and excluded facial expressions in order to identify communicative value and to label individually expressed emotional and whole-body gestures. The third study focuses on emotions as numbers, by using kinematic, quantitative data of expressive gestures as sample data intended for the visualisations. The triangulation process, which partly uses the kinematic data, aims to find the correlation and differences among expressions. The aim of both these approaches was to provide an extended view on the visual qualities of emotions and their communicative values.

2.2.5 Qualitative Research

Practice-led, qualitative research has accompanied the video data collection and analysis of movement classes, where performative experiments were conducted and evaluated collectively through discussions during workshops. The workshops were arranged in collaboration with the Nordplus Higher Education DAMA network and have encompassed students and teachers from performance art, dance, media art and game departments from universities across Northern Europe.

The workshops took place in Tallinn, Estonia; Reykjavik, Iceland; and Visby, Sweden. This phase of the research concluded with the pedagogical toolset discussed in section 4.2 *Pedagogical Toolset.* The final phase of analysis of the documents provides material for the database, including graphical illustrations of movement timelines. Additionally, comparisons of emotions in the form of video data have been compiled using the Korsakow tool (Thalhofer, 2007) as an example of corporeal narratives based on the aesthetic values of movement.

Finally, an ocular triangulation method was used where visualisations of statistical data were compared with video timelines. The method used involved superimposed video frames converted to chronophotographic images and Silhougraphs® (Kealiinohomoku, 1989). The approach used in this part of the study, is a combination of artistic and scientific methods where hypothetical constructs or idealized states are used to compare emotive expressions in terms of their particular visual properties and characteristics such as: shape, space, volume, time and expression, similarities, differences and communicative qualities. The parameters used for the evaluation within the context of game character development included; expression clarity, and in the context of movement sensing devices; expression readability.

The process and the methods used during the research are visually explained in the document *Methods in The Context of The Timeline and Purpose* presented in figure 2.3 and in Appendix B (scale 1:1)

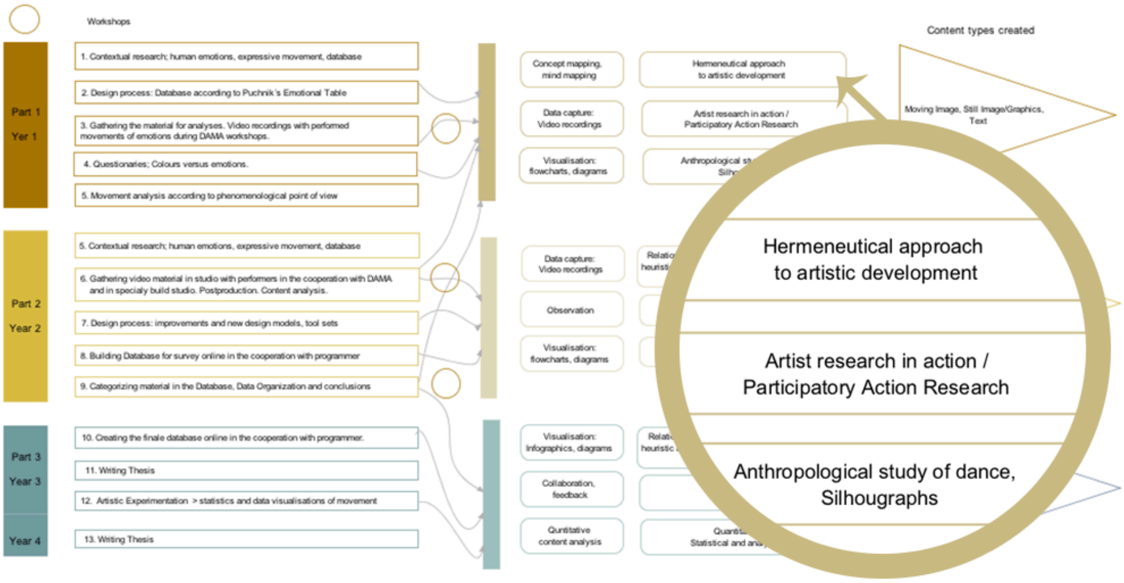

Figure 2.3 Methods in The Context of The Timeline and Purpose, Hrynczenko, 2010.

2.2.6 Collaboration & Collaborators

The development of expressive movement documentation and the PTM database would be impossible to achieve without the cooperation of others. The main collaborator is DAMA, supported by the Nordic Council Nordplus for Higher Education Program. DAMA is an interdisciplinary network project that integrates media art and dance students, teachers and practitioners from art schools and universities in European Nordic and Baltic regions, of which I am a member as lecturer and organiser. The purpose of this network is to support knowledge exchange between students representing dance and interactive media art cultures. This provides a platform for experimentation and also to build and share a unique educational program in which dance and performative practices are combined with interactive audio-visual media and game play.

The DAMA network and workshops supports an endeavour for the development and discovery of new pedagogical methods as well as validating their use in academia. The participating DAMA members are:

Danish National School of Theatre and Contemporary Dance (Denmark)

Estonian Academy of Arts (Estonia)

Gotland University (now part of Uppsala University/ Campus Gotland) (Sweden)
Iceland Academy of the Arts (Iceland)
Malmö University (Sweden)
Northern Lithuania College (Lithuania)
Riga Teacher Training and Educational Management Academy (Latvia)
Tartu University (Estonia)
Turku University of applied sciences (Finland)
University of Akureyri (Iceland)
The coordinating institution was the University of Lapland (Finland).

In the context of this research the DAMA workshops became the environment in which creative co-production of knowledge took place, contributing to my research with new insights and creating new forms of enclosures that accompanied the process. Each workshop involved collaborations, creating new relationships and experiences, outlined by realistic and practical scenarios that provide new tools, techniques and methods for the development of my own research. In practice, most of the video material of expressive movement was recorded during the workshops with the help of workshop participants. The first survey, a study on colours versus emotions, took place during the workshop in Tallinn, followed by discussions and the implementation of ideas by participating students and teachers. On two separate occasions, I was able to use studios and equipment to achieve a high standard of video and data acquisition. Importantly, the pedagogical toolset was developed as part of the workshops and was used within these to provide a platform for evaluation and discussions. Additionally, they contributed to cross-disciplinary education, where physical movement in the form of specific exercises could be integrated into the workshops.

Important support for this research came from the Game Design Department at Gotland University (today, Uppsala University/ Campus Gotland), where I worked as a teacher. The university provided financial support as well as equipment, facilities, technical support and the possibility of participating in research meetings during 2010.
During this period of time, research meetings were organised by The International Research School of Game Design (IRSGD), a collaboration between Uppsala University and Gotland University. The three meetings and one symposium (The Future of Game Design) allowed information exchange relevant to my thesis. Specifically, I received useful feedback from Professor Nakajima (Nakajima Lab Gotland, Tokyo

Institute of Technology) and Mirjam Palosaari Eladhari, both then researchers at Gotland University. Both of them pointed out the importance of a validation process of the movement library. Their input and guidance contributed to the online *Expressive Movement Evaluation Survey*, providing a coherent grounding for the research.

During the development of the online survey I cooperated with Błażej Pindelski, a software developer for the Open Microscopy Environment based at the Wellcome Trust Centre for Gene Regulation & Expression, University of Dundee, Scotland, U.K. where he currently works on client-server software aimed at microscope image processing and storage. In the PTM research project, he was responsible for the set-up and maintenance of a *LimeSurvey* (LimeSurvey Project Team and Schmitz, 2012) instance and for the implementation of a database and web-based application for browsing and searching emotions contained in video material. His involvement was essential for the validation process of the video material as well as for the construction of the PTM database.

The experimental part of this doctoral study, including the visualisation of quantitative data and the experiments on the possible use of Kinect (Microsoft, 2010) as an interface, engaged the cooperation of a student at Heriot-Watt University, Edinburgh, Scotland, U.K. and co-founder of Edinburgh Hacklab (2010), Ioan Maria Stacewicz, visual artist and programmer, previously involved in the *Shadow Dance* (2009a) project. Most of the experiments were based on the adaptation of Kinect's motion recognition ability to the interface of the PTM database, which is still an on going project. However, the outcomes of this cooperation is evident in the data visualisation thanks to Ioan Maria's adaptation of the Circos libraries' programming language, Perl, to the specific requirements necessary to obtain the final result of the visualisation model, based on statistical data from the *Expressive Movements Evaluation Survey*. Circos (Krzywinski *et al*., 2009) is an open source software package developed and originally designed for the visualization of genomic data. Circos based on the Perl (Wall,1987) programming language visualises data in a circular layout providing an overview of the correlations among the groups in one dataset.

2.3 Ethics

The research was carried out according to Duncan of Jordanstone College of Art and Design's ethics guidelines (Appendix E) and the University of Dundee Ethics and Research Governance Policy (University of Dundee, 2011). Prior to the video recordings, participants were given a *participant information sheet* describing the research project, their involvement and its context as well as the contact details of the researcher. After reading the information, each of the participants was asked to sign a *participant informed consent form* that included permission to use the data collected in the research project. Participants in the online interactive survey were presented with an information page at the start of the survey, which provided the information required to satisfy the ethical guidelines. Specifically, the participants were informed that by pressing the submit button they gave permission to use their answers in the study.

Additionally, attendees participating in the video recordings were provided with a *Release form for individuals* that provided information about the date of filming, program working title, client, subject's name, address, location and release text. The release text contains a statement that assigns the copyright to the researcher under the 1988 Copyright Designs and Patents Act or any similar laws of any jurisdiction. In addition, permission was granted for the material to be used in the context of previously formulated research and in any media in perpetuity throughout the world. The statement included an agreement that the material will only be used for educational purposes. After reading the information, each of the participants was asked to sign the *Release form for individuals.* A copy of the format for the document is available in Appendix E.

3 Contextual Research: A Journey in Three Parts

3.1 Introduction

The contextual research is an attempt to interpret and formulate existing aspects of the ideas of human corporeality and emotions against the background of technological advancement. The intention here is to objectively contextualise and reflect on them, preserving subjective reflections as a parallel process in order to encompass the scientific view with the more subjective/intuitive view of a media artist or performer. In this chapter a parallel first person narrative is used, with the intention of emphasising the creative processes and the thoughts behind them, and uses a method based partly on a phenomenological point of view.

The emphasis of the contextual research is focused on concepts of emotion, presence, visual perception, emotions in games, perceptual interfaces and movement recognition, as well as data visualisation. My aims with this approach are threefold, firstly to contextualise the empirical part of this study in terms of existing knowledge in these areas. Secondly, to underpin the methods used in relation to existing motion sensing technology. Thirdly, my aim is to highlight existing knowledge about the human body's expressiveness that could be useful in game design and graphics education by critically compiling examples of art, science, dance and performance art.

At the start of the research at least three different layers: emotions, movements and the database, required to be taken into account. These were based on different perspectives of the topics, namely: performance art, moving images, movement data visualisation, and the field of human perception. During my investigation, I was astonished by the large scale of these fields and realised that answering the following questions is key to the overall approach of the investigations:

What is Emotion? Are emotions expressed via movement and gestures equally recognisable across cultures? How can these expressions be visualised and digitalised? How can emotion be explained in the context of corporeal movement in order to be measurable? All of these questions become equally relevant to the main research question, which has been repeated across the chapters as a mantra:

How can emotions expressed via the whole-body movement be visually documented and archived as a reference framework to stimulate the use and studies of expressive gesture in digital environments?

Therefore, this study was divided into three areas: *Emotions, Science, Art and Virtual Worlds* - investigating the issue, *Movement, Body, Art and Technology* - searching for patterns, and *Database, Movement and Data Visualisation* - packaging it all together with the help of digital technology. All of these related sections were equally crucial for the implementation of the predefined idea. This chapter outlines the multifaceted context in which the research is situated, and presents the sources of information and inspiration reflected in the thesis. The semantic division of the chapters is symbolic since, in the real world, the ideas, research and artworks included overlap, creating synergies, dependencies and interactions throughout their development. Nevertheless, this partitioning is an attempt to provide a logical structure for the thesis.

During this phase of the research, I considered the thoughts that were most influential in shaping my views, and compared them with scientific theories, some of which are outside the scope of this research. The following three chapters reflect the journey of the research, partly in a subjective way. They contain autobiographical elements and personal and philosophical detours, which I believe have coloured the entire research, and thus were found to be relevant to review in the methods section, described in Chapter 3 *Strategy.* Each of these chapters begin with a short introduction, and finishes with a summary of the conclusions. The whole chapter ends with a discussion that summarises all the findings and aligns them in the context of this doctoral study.

The first section, *Emotions, Science, Art* and Virtual Worlds describes explorations in the fields of philosophy and psychology and the applications of new technology within the arts related to human emotions. The second part, *Movement, Body*, *Art and Technology* contextualises, performance art, film, and the notion of presence embodied in human computer interaction (HCI), in terms of their histories. This chapter also discusses dance and performance technology as well as body movement in games research.

The investigation described in the third part, *Database*, *Movement and Data Visualisation*, focuses on conceptual and technical issues connected to the PTM project and the concept of database as artefact. The project and knowledge areas are visually

mapped to diagrams to show their connections in a cross-disciplinary knowledge map (CDKM), Appendix C which illustrates the correlations of different knowledge areas to the PTM database (Appendix C).
It was developed using the *Visual Understanding Environment* (VUE) (Tufts University, 2003) open source software mapping tool created by Tufts University.
It was also an attempt to convey the paths taken in the phenomenological inquiry. The contextual research and the CDKM partly refer to scientific areas that are connected to the PTM, and were used to search for information beyond my own area of knowledge. My intentions, when crossing discipline boundries, were based on the need to justify my arguments in a broader context. Equally, I was required to find answers, which my knowledge field could not provide. My intention was less to study all of these disciplines in great depth, but rather to investigate relevant areas connected to the PTM idea, and employ a different perspective to foster my own understanding. At the same time I recognised the opportunity to utilise existing knowledge contained in the field of performance art that could bring a different perspective to the field of game design.

The contextual research started with an investigation into the extent to which expressive movement and gestures are represented across the discipline areas and how these are characterised in relation to the key subjects of this investigation. These main areas of focus include emotions, cognition, embodiment, corporeality, technology, interaction design, perception, embodied perception, expressive movement and gesture.

3.2 Emotions, Science, Art and Virtual Worlds

> *Although many of us may think of ourselves as thinking creatures that feel, biologically we are feeling creatures that think.*
> *Jill Bolte Taylor (2006, p. 19).*

The aim of this section is to describe six different perspectives on emotions in order to explore the exciting and complex theories and ideas on what emotions are and how we perceive them. The section maps emotions through a series of scientific statements and artistic explorations, some of which I found more challenging than others. Therefore, I have added my own perspective as a reflection and comment.
The multi-faceted approach allowed me to identify the essential elements that have guided the development of this project and to combine these five perspectives to form the research by integrating components of separate viewpoints. They are considered as a whole concept consisting of scientific perspectives, subjective viewpoints, Plutchik's psycho-evolutionary perspective, artists' interpretations and contributions from games research.

3.2.1 Scientific Perspective

The word 'emotion' is derived from the Latin '*motere*' that means movement, which ties it to physical actions. In western traditions, emotion has been seen as the opposite of reason; explained as '…agitation, perturbation, and feeling or affection in opposite to the cognitive or volitional states of consciousness' (Oxford English Dictionary, via Oxford Handbook of Religion and Emotion, 2008, p. 18). Descartes (1644) cemented this division when he famously postulated: "*Cogito ergo sum",* i.e. "I think, therefore I am", which is a simplification of his original statement, strongly associating emotion with the body, while reason remained the domain of the mind. Damasio (1994) in his book *Descartes' Error* highlights this classic mind/body problem and connects cognitive processes to the human body. These different views highlight the ongoing discussions across different fields of knowledge where the relationship between the cognitive and somatic experiences of emotion is investigated.

Modern psychology presents various views on this debate, sometimes in juxtaposition with one another. On the one hand, there is distinction between two minds: 'Our two minds.... One is an act of the emotional mind, the other of the rational mind. In a very real sense, we have two minds, one that thinks and one that Feels' (Goleman, 1996, p.

8), while on the other hand, as previously cited, Seitz proposes a strong correlation between the body and mind: ‘We do not simply inhabit our bodies, we literally use them to think with’ (Seitz, 1993, p. 1).

Numerous disciplines have investigated emotions in order to provide definitions and categorisations. Although the multidimensional nature of human emotion causes difficulties in producing a transparent and solid description of what emotions are, Lindsley (1951) explains the problem of uncertainty as depending on as many levels as the human organism is constituted:

> Emotion is one of the most complex phenomena known to psychology. It is complex because it involves so much of the organism at so many levels of neural and chemical integration. Both subjectively and objectively its ramifications are diffuse and intermingled with other processes. Perhaps therein lies uniqueness, and possibly the major significance, of emotion (Lindsley, 1951, p. 473).

Most scientists agree is that emotion is strongly connected to human survival instincts, however different disciplines present a large number of ideas, hypotheses and theories on the nature of this connection. No definitive taxonomy of emotions has been formulated, although according to Plutchik (2001 p. 344), there are over ninety definitions of emotion. Most theories in psychology regarding the process of emotional reactions differ. The theories can be divided into those who claim emotions are based in physiological arousal, i.e. a non-cognitive feeling of bodily changes, and those who argue that a conscious, cognitive experience is the pivotal process during an emotional experience. A secondary distinction regarding stimuli is outlined by Schachter and Singer's Theory (1962), who define emotion as a reactive system that depends on external and internal stimuli. According to this theory, emotional feelings and behaviours are the products of information from 2 systems: Internal state – hypothalamus and limbic system and the external environment (context in which the internal state occurs) (Schachter and Singer, 1962).

The theoretical distinctions between emotional reactions, in terms of cause and effect, depend on the series of actions between the cause of the emotion, which may be internal or external, and the outward expression of the emotion, which depends on physiological reactions. Most scientists describe the process as a linear one, and in order to exemplify the differences diagrams from AllPsych (2004) are used:

EVENT ····➔ AROUSAL ····➔ INTERPRETATION ····➔ EMOTION

Figure 3.1 James-Lange theory, Diagram according to AllPsych, 2004.

The diagram in figure 3.1 displays the James-Lange Theory (Lang, 1994) that inspired Meyerhold when developing biomechanics (Mayer-Dinkgräfe, 2001, p. 78). James and Lange (1884) independently proposed that emotion appears as a result of physiological reactions to stimuli. The Cannon-Bard theory introduces a concept of simultaneous experience where a stimulus activates an emotion and the physiological reaction at the same time, preparing the body to react to the situation (figure 3.2).

····➔ AROUSAL
EVENT
····➔ EMOTION

Figure 3.2 Cannon-Bard theory, Diagram according to AllPsych, 2004.

Schachter and Singer's Theory (1962) presents the cognitive process as essential in terms of execution of emotion presented in figure 3.3.

EVENT ····➔ AROUSAL ····➔ REASONING ····➔ EMOTION

Figure 3.3 Schachter and Singer's theory, Diagram according to AllPsych, 2004.

This theory suggests that arousal is the first stage of cognitive activity, enabling reasoning, the evaluation of the situation that leads to conclusions, which cause the reaction, i.e. the emotion. Lazarus (1991) however argues that thought is the primary action, enabling both emotion and arousal at the same time, as represented in figure 3.4.

····➔ EMOTION
EVENT ····➔ THOUGHT
····➔ AROUSAL

Figure 3.4 Lazarus theory, Diagram according to AllPsych, 2004.

The Facial Feedback Hypothesis initiated by Darwin (1872, p. 366), suggests that facial expressions are a result of genetic factors (figure 3.5). Darwin's hypothesis was evaluated in different iterations through the years; however very recent studies on the effects of Botox injections have indicated that facial muscle paralysis affects the ability to feel emotions (Havas, *et al.,* 2010) suggesting that emotions can be provoked by movement of the facial muscles. This opens the possibility for a new theory; that physiological changes can affect emotional behaviour.

EVENT ····➔ FACIAL CHANGES ····➔ EMOTION

Figure 3.5 Facial Feedback Hypothesis, Diagram according to AllPsych, 2004.

Figure 3.6 Facial expressions, Cambridge University Library, Duchenne, 1862.

The Facial Feedback Hypothesis and the reverse method of using expressive movement to provoke emotions, if extended to whole body movement, are both supported in methods used by Gurdjieff and as well as training techniques in Performing Arts discussed in section 3.3 *Movement, Body, Art and Technology*. Furthermore, the Facial Feedback Hypothesis provides arguments for the reverse reaction, which according to Isbister (2011) (discussed in section 3.3.9 *Physical Body, Emotions and Games*), shows that movements can stimulate emotions as a positive behaviour.

It seems that Darwin's idea is still interesting in the context of emotion versus perception as during 2012-2013, the University of Cambridge's Darwin Correspondence Project (2012) ressurected his idea for a new evaluation. His study was re-created using the same images, taken by the French physiologist Benjamin Duchenne in 1862 (figure 3.6). According to the information published by the Darwin Correspondence Project (2012), more than 18,000 test subjects participated in the online survey. The responses to each photograph, however, were extremely diverse. According to the Darwin Correspondence Project (2012, unpaged) the results of the survey reflect Darwin’s previous conclusion ‘...that some of these artificially created facial expressions convey a particular emotion more convincingly than others.' The results also show that, ‘…over 50% identified photographs 2 (surprise), 3 (terror), 4 (grief and despair) with the correct or very similar emotion’ (Darwin Correspondence Project, 2012, unpaged).

In the context of quantifiable emotion, (i.e. the epistemological approach) the measurements of emotional expressions were considered generally in the area of psychology and focused mainly on facial expressions. Maximilian Wundt introduced in 1858 in *Die Lehre von der Muskelbewegung* (*The Patterns of Muscular Movement*, 1858) the physical dimension of emotions in psychology as presented in his *Principles of Physiological Psychology* in 1874.
There are several measurement systems that developed over the years grounded in his work, one of them, the emotional state model *Pleasure, Arousal, Dominance* (PAD) was introduced by Mehrabian and Russell (1974). It is a measurement model based on three quantifiable dimensions to represent emotions based on *Self-Reporting Questionnaires* (SRQ) where respondents react to visual stimuli. The first Pleasure-Displeasure Scale refers to measurements of pleasant or unpleasant feelings about a specific experience. The second, The Arousal-Nonarousal Scale measures mental alertness in combination with a physical activity. The third one, the Dominance-

Submissiveness Scale, refers to respondent's bipolar descriptions such as satisfied-unsatisfied, controlling-controlled and exited-calm. Mainly, this scale focuses on the participant's description of the degree of control over their own physical experience and social environment. In the context of virtual environments, three-dimensional PAD scales have been used in the design of animated intelligent virtual agents for example, an approach described in the research of Lance, Brent *et al.* (2008) and Zhang *et al.* (2007).

Today several methods exist that measure the affective factors in the context of user experience assessment (UXA) in which some of them are related to the experience of emotion or could be used as such for their measurement. Relevant examples would include the *Geneva Emotion Wheel* (GEW) whch is a self-report based on respondents experience of emotion by choosing intensities for a single emotion or a blend of several emotions out of 20 distinct emotion families (Baenziger *et al.,* 2005). *Emotion Slider*, a self-report device for the continuous, non-verbal measurement of emotion based on a mechanical slider connected to computer software and a questionnaire. The main idea with this interface is to show that answers are physically embodied and intuitive (Laurans *et al.,* 2009). The *Sensual Evaluation Instrument* is a toolset of sculpted objects that can be held in the hand, used by a person to indicate how they feel as they interact with a system designed to evoke affect (Isbister *et al.,* 2006).

In considering theories based on linguistics, such as the theory presented by the linguist George Lakoff and philosopher Mark Johnson (1999), the human body by operating in a material world is dependent on a set of physiological processes. These in turn are providing the foundation for the most central concepts such as metaphors that organise the language we use and the way in which we understand our surroundings. According to Lakoff and Johnson (1999, p. 266), 'There is no mind separate from and independent of the body, nor are there thoughts that have an existence independent of bodies and brains.'

Prinz (2004) claims in his embodied appraisal theory that emotions are perceptions of changes in the body that enable us to sense danger, loss, and existential needs. The following statement reflects the core issues of this research articulating the need for a deeper understanding of the communicative properties of expressive movement.

> Our perceptions of the body tell us about our organs and limbs, but they also carry information about how we are faring. Is this the view that James and Lange had in mind? Probably not. Their contributions predate the relative developments in philosophical thinking about representation. But the embodied appraisal theory preserves their core insight, and endows emotions with semantic properties that can be used to deflect the arrows of dissent. In developing a theory of emotion, we should not feel compelled to supplement embodied states with meaningful thoughts; we should instead put meaning into our bodies, and let perceptions of the heart reveal our situation in the world (Prinz, 2004, p. 58).

Damasio's (1994) "somatic marker hypothesis" summarises the relationships between cognition, emotion and body, and in particular that rational decision-making is conditioned by bodily emotional responses. According to Damasio (1994), we may be unable to make decisions using only cognition. He postulates that without emotions cognitive processes may become overloaded. Emotions motivate an individual to perform an action affecting the choices in decision-making. Somatic markers are associations among empowering stimuli that evoke a related physiological affective condition. This leads us to the phenomenological point of view, that the physical body plays a central role in how we perceive the world; therefore, it can be construed that certain emotions are similarly expressed and perceived across cultures. The issue is investigated further in the present study.

These cross-cultural and universal aspects are significant issues for the PTM database and its future applications. Consequently, the necessity for the universal nature of the database required contextual research of existing cultural and geographic similarities in the perception of emotional expressions. The findings of this study provided the foundations for the database development.

Emotion Representation and Perception Across Cultures, Online Readings in Psychology and Culture by Altarriba *et al.* (2003) is a review based on analyses of perceptions of emotions across cultures. The authors refer to the existing research on linguistic and facial expression based on several decades of previous cross-cultural research. The authors summarise that there exists an element of universality for both linguistic and facial expression recognition pointing to six basic fundamental human emotions (Altarriba *et al.*, 2003). However, the authors also highlight that the previous research contains some weaknesses regarding the methodology, especially, those based on linguistics, which depends on the variation of names given to commonly occurring emotions.

In the context of the PTM database, the definition of common basic emotions plays a central role, primarily because the choice of emotions provides a basis for the database both fo andr during the research, and by extension, in its future development. From a cross-cultural linguistic perspective the primary emotions are: "anger", "fear", "happiness", "sadness", and "disgust" (Russell, 1991, via Altarriba *et al.*, 2003). This is similar to Plutchik's definition that was chosen as a model for this research. Mesquita *et al.* (via Altarriba *et al.*, 2003), however, proposed a smaller number of emotions, including only sadness, joy, anger, and fear. Fridlund, Ekman and Oster's (1987) literature review on facial recognition supports the previous research, however, concluding that six basic emotions – happiness, surprise, fear, sadness, anger and disgust correlate extensively across different cultures. Taking into consideration previous research on the universality of emotional expressions and Plutchik's theory, only four emotions; anger, fear, joy and sadness, became a choice for my study on visual elements of embodied emotion. The previous research on the universality of physical expressions is based on facial expressions, whereas, the material used for the database is evaluated in terms of whole body expressions providing background information for the database.

When looking at emotions that are expressions of feelings, which are conditioned by culture, the Socio-anthropological perspective and ethno-theoretical ideas play an important part in how, when and to what extent emotions are expressed. Sociologist and anthropologist, Marcel Mauss (1872-1950) introduced in 1934 during one of his lectures, the term ‘techniques du corps’ referring to how social factors act on the postures and expressions of the physical body (Mauss, 1979/1935, p. 104). He explains these ‘body techniques’ as ‘the ways in which from society to society men know how to use their bodies’ (Mauss, 1979/1935, p. 97). Mauss refers to ‘special habits’ (Mauss, 1979/1935, p. 99) as a part of social adjustments, such as differences in the gaits of French and American women, English and French soldiers way of marching, French children’s postures at the dinner table, and how the generations of Frenchmen had been taught to run and swim (Mauss, 1979/1935, pp. 98-101). Mauss explains the ‘special habits’ as:

> These ‘habits’ do not just vary with individuals and their imitations, they vary especially between societies, educations, properties and fashions, prestiges […] In them we should see the techniques and work of collective and individual practical reason rather than, in the ordinary way, merely the soul and its repetitive faculties. (Mauss, 1979/1935, p. 101).

Similarly, socio-anthropologist, Catherine Lutz (1986, p. 5) provides a view of emotion as ‘culturally defined, socially enacted and personally articulated’, therefore, conditioned by the socio-cultural environment. She claims that ‘emotional experience is not precultural bur *preeminently* cultural.’ (Lutz, 1988, p. 5). Furthermore, she states that:

> Concepts of emotion can more profitably be viewed as serving complex communicative, moral and cultural purposes rather than simply as labels for internal states whose nature or essence is presumed universal (Lutz, 1988, p. 5).

For example, reflecting on American gender associations of the 1970's, Lutz (1988) describes a cultural view of women and emotion from a historical, scientific perspective. Emotion was regarded as ‘... a “mental health” problem or as an animal or mammalian trait rather than as a particularly human, intelligent, and social adaptation’ (Lutz, 1988, p. 16). Lutz points to a culturally contingent gender relationship in which emotion linked to the female gender is devalued in relation to rational thinking.

3.2.2 Emotion From the Philosophical Perspective of Phenomenology

Looking at emotion from the perspective of phenomenology, Merleau-Ponty (1971) contextualises emotion in terms of bodily expression. Emotion is what makes our gestures, postures, facial expressions and spoken words perceivable by others by which we can relate to the world through collectively shared bodily expressions. In particular, Merleau-Ponty confronts the way emotion has been looked at and measured by science by pointing at obvious visual, perceivable aspects shaped not for its own purpose but in the context of 'the other'.

> We must reject the prejudice which makes inner realities out of love, hate or anger, leaving them accessible to one single witness; the person who feels them. Anger, shame, hate and love are not psychic facts hidden at the bottom of another’s consciousness: they are visible from the outside. They exist on this face or in those gestures, not hidden behind them (Merleau-Ponty, 1971, p. 52).

Most of the time, the expressions have a receiver. Gesture, the body’s movement and its position have a meaning in the context of others, acted and interpreted in a dialogue. Emotion as described by Crossley (1995, p. 145) is ‘embodied, as inseparable from bodily practices such as gestures, rooted in the intimacy and immediacy of instantiated

or corporeal interchange: face-to-face, body-to-body'. Crossley's reflection is presented here as an insight from the perspective of sociology mirrored in phenomenology.
Taking into account the approach of this study, a first person perspective and the affect reflected in the human body, I refer back to phenomenology. Merleau-Ponty (1962) defines the interpersonal exchange of body language as "inter-corporeality" which Van Manen (1990) explains as the "lived other" (relationality) always in co-existence with the other two "live worlds": "spatiality" and "temporality". In terms of this research, I took into consideration the communicative properties of emotion by evaluating and visualising the objectified communicative value of documented expressions with the objectified, subsequently seen from the perspective of 'the other'.

3.2.3 Subjective Perspective

I believe that the human body is a memory container, with an immense database of memories, beyond the cognitive control of its owner. It is a security system, communication network unit, interface and parallel operating system that connects us with the environment and one another. This belief is built upon my own experiences and influences aquired along the way. The choices I have made, unconsciously and consciously, reinforce this view. Throughout this journey, I have allowed myself to be influenced, and have sought answers through alternative means, and have reflected on what I have found through the lens of phenomenology, a context in which reality is reflected through the human senses in a dynamic relation of body-mind-world. This may be explained by the holistic view that phenomenology provides, as in Merleau-Ponty's (1962) reflection, here used as a comment on the previously presented review of theories of emotion, which describes the body and mind as a unified whole. 'The fact was overlooked that, in order to express it, the body must in the last analysis become the thought or intention that it signifies for us' Merleau-Ponty (1962, p. 197).

Personal reflections are used to provide perspective on artistic processes, in which this parallel track reflects my philosophical detours during the transformation of emotions as nonverbal information to numbers. This conversion becomes a reason for philosophical detours that are reflected on during the research process.
Emotions can be seen as a combination of different factors, and are a complicated subject to discuss. They are an inner pre-verbal state beyond descriptive models, yet are intriguing since they are such a crucial part of human life.

During my apprenticeship, in Grotowski's (1933 – 1999*) paratheatrical* training in Brzezinka summer camps in 1973 and 1974, my goal was to reach beyond the protective shields of emotion to search for a clear way to perceive the world. Grotowski's methods, known as *Paratheatre,* presuppose a theatre without audience or stage where most exercises were based on rituals to find the expressions that exclude the notion of the self. However, by confronting the self on many possible levels, I discovered that only via the emotional state of my body could I reach the state of an *open-presence*. I achieved this, not as an individual body, but as part of the space that embraces everything in it, including other bodies, almost as connected cells. It was, perhaps, an extreme state of awareness. With this new personal discovery, I turned to *Butoh*, looking for answers through the body's transmutations into other forms, searching for the common denominators in life.

The open form of *Butoh* allowed some experimentation, and during the training I learned that emotive expressions when exaggerated could become highly individual.
As a result of my previous experiences it has become obvious to me that an important parameter in daily life is to raise awareness of the human body in motion, a tool that can improve mental and physical well-being. Movement exercises can be applied to all levels of life, as part of daily routines or as part of entertainment and gaming.
It seems that European cultures tend to divide the human existential and driving sources in two juxtaposing camps: emotion and reason, followed by distinctions such as body and mind, arts and science. These polarities express a human need for balance and labelling. However, it seems that a hierarchical value was declared between emotion and reason. The structural change, which positioned intellect over emotion, as a non-cognitive dimension, has affected the allocation of educational and economic resources and has shaped human cultures through education, economy, politics and technological development causing alienation from nature, ourselves and each other.

This need for a hierarchical validation system may have roots in the fact that we have been able neither to master emotions, nor to understand them; therefore, we have chosen to some extent to control them by their denial. I believe that this occurred long before the Cartesian influences, in the time of "scarification" of the body as a representation of the destructive part of human nature, introduced by Christianity in Early Middle Ages (Eliade, 1958). Perhaps, the denial of the physical body has created a need for compensation, expressed in rituals, and later theatre, then movies, which we have in modern times simplified to passive consumption of continuous flows of information, and labelled as a need for entertainment.

Let us say that we manage to place emotions at a safe distance allowing us to celebrate, analyse and discuss them as distant objects, experienced through objectified bodies and symbolical representations of things. This has not yet brought us closer to the controlling ability of emotional effects and the impacts these have on our daily lives. Through the whole of human history, we cannot deny that many of our personal as well as historical decisions are the effect of minds controlled by emotions.

This paradox was always intriguing to me. I have therefore spent time analysing my own and others' emotions and emotional expressions to determine the factors that prevent us from expressing them, and the level at which we manage to block the physiological reactions. In order to approach these concerns, I needed to establish a model that could include multidirectional interactions in contemporary technology, as discussed in section 3.3 *Movement, Body, Art and Technology.*
I have assumed from my earliest inquiries into these topics, that emotions were strongly reflected in the body. This would function in two directions: firstly those emotions affect physical expressions, and secondly that specific movements can provoke certain emotions. In addition, watching the expressive movements of others can often awake emotions in us. For example, direct emotional contact awakes reflective emotions in us, which are often different depending on the situation. Similarly, observing expressive movements as a third person, for example, watching dance or theatre can lead to an emotional experience. When we experience the emotions of others, the result can be empathetic.

In the eighteenth century, the Scottish philosopher Adam Smith (1790) postulated underlying issues of what can be characterised as the "empathetic" behaviour in his theory of "sympathy":

> As we have no immediate experience of what other men feel, we can form no idea of the manner in which they are affected, but by conceiving what we ourselves should feel in the like situation (Smith, 1790, unpaged).

The concept of empathy is often related to Lipps' theory of Einfühlung ("feeling into," "empathy"), which he describes as a process that allows the contents of "the minds of men” to become “mirrors to one another” (Montag *et al.*, 2008). Lipps' interest in art and aesthetics extended this view, which describes empathy as the act of projecting oneself into the object of a perception. Lipps explores this perception in the context of aesthetic empathy as the perception that ‘...could be exemplified by the actor or singer who genuinely feels the part he is performing. With other works of art, a spectator may, by a kind of introjection, feel himself involved in what he observes or contemplates’ (Lipps via Encyclopaedia Britannica, 2013, unpaged).

The human potential for empathic reactions from the perspective of cause and effect, could create a potential problem, for example, if we do not expose ourselves to a visual daily dose of emotional expression, there is a possibility that our sensitivity may be reduced. Another potential problem is the stimulation of an opposing action, which results in the same effect. In this second case, it is possible that an ‘overdose’ of visual, emotional stimuli, can reduce emotional output by preventing the interpretation of the original emotional input. Preston and de Wall (2002) describe empathy as a result of a visual mapping of another person's behavioural state, which activates in the observer emotional responses:

> When this process is utilized for processing emotional information, emotional contagion, empathy, and cognitive empathy result. It is an adaptive structure that allows individuals to use the same tissue for representing self-action and understanding the actions of others, in both cases, facilitating a response from input (Preston and de Wall, 2002, unpaged).

Furthermore, Preston and de Wall (2002) make a reference to human evolutionary processes, highlighting that the human ability to distinguish and classify facial expressions, body postures, gestures, and voices is linked to the development of the central nervous system, which has adapted to the complex social system of primates. This development supports the need for the quick responsiveness of emotions for communication and survival. This is true throughout human history. This assumption is an underlying factor for this research and is explained in the next section.

3.2.4 Plutchik's Psychoevolutionary Perspective

Through the analysis of existing theories in psychology, I became interested in the ideas that propose a model that takes into account the possibility of a two-directional process, which I discovered in Plutchik's Psychoevolutionary Theory of Basic Emotions. Plutchik's theory explains how emotions are executed, presenting emotional effects as a feedback process, not as a linear event. This is based on the adaptive pattern of behaviour necessary for survival (Plutchik, 2001, p. 347).
Plutchik has positioned emotion within the context of territoriality, identity, temporality and hierarchy (Plutchik, 2001, p. 350), all compatible with the phenomenological "existentials" and the heuristic guides implemented in the course of this investigation: Spatiality - Lived Space, Corporeality - Lived Body, Temporality - Lived Time, Relationality - Lived Human Relation (van Manen, 1990, p. 102).

Plutchik's psychoevolutionary theory of basic emotions has ten postulates. It served as a starting-point in the project's construction:

1. The concept of emotion is applicable to all evolutionary levels and applies to animals as well as to humans.
2. Emotions have an evolutionary history and have evolved various forms of expression in different species.
3. Emotions served an adaptive role in helping organisms deal with key survival issues posed by the environment.
4. Despite different forms of expression of emotions in different species, there are certain common elements, or prototype patterns, that can be identified.
5. There is a small number of basic, primary, or prototype emotions.
6. All other emotions are mixed or derivative states; that is, they occur as combinations, mixtures, or compounds of the primary emotions.
7. Primary emotions are hypothetical constructs or idealized states whose properties and characteristics can only be inferred from various kinds of evidence.
8. Primary emotions can be conceptualized in terms of pairs of polar opposites.
9. All emotions vary in their degree of similarity to one another.
10. Each emotion can exist in varying degrees of intensity or levels of arousal. (Plutchik, 1980, 1984)

Plutchik's postulates are presented as a colour metaphor of emotions, visualising complex emotions as variations of eight mixed primary emotions. This division is presented in a circular structure and composed of four bipolar pairs: Joy v. Sadness, Acceptance v. Disgust, Fear v. Anger and Surprise v. Anticipation (figure 3.7).

Plutchik (2001) identifies and contrasts the primary emotions according to position of primary and complementary colours in the colour wheel:

> I have found that the primary emotions can be conceptualised in a fashion analogous to a color wheel-placing similar emotions close together and opposites 180 degrees apart, like complementary colors. Other emotions are mixtures of the primary emotions, just as some colors are primary and others made by mixing the primary colors (Plutchik, 2001, p. 349).

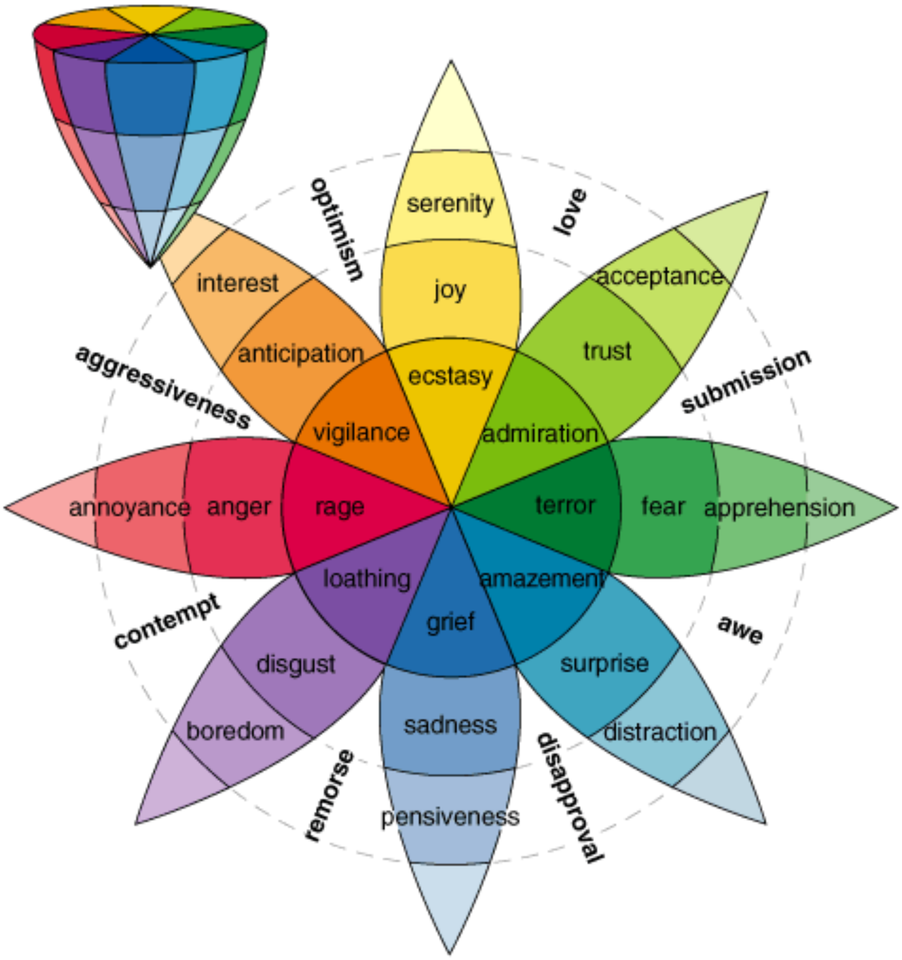

Figure 3.7 Plutchik's colour wheel of emotions (circumplex), Plutchik, 1980.

One of the reasons I chose to base this investigation on his research was that it proposed a structure with a deeper perspective, related to "the whole". Moreover, Plutchik's approach corresponds to the need for a semantically consistent number of distinct emotions and a transparent organisational structure in the study, as it offers a solution in the form of ten postulates. These identify basic emotions as elements derived from the original behaviour, classified as four Primary, eight Basic Secondary and eight advanced Tertiary emotions, with their correlations shown in two and three dimensional models as illustrated in figure 3.7.

In 1994 Plutchik noted that verbal expressions of individual emotion have different intensities, therefore he extended the relational circumplex by adding an intensity dimension corresponding to emotional intensity, which could be compared with the intensity of colours. These were arranged into an outline of 32 emotions, according to the emotional phenomena and colour analogy. I found this to be an interesting aspect of Plutchik's theory, and his indirect support for the idea of specific movements as "biological" expressions (Barba and Savarese, 1991), to be relevant.

Plutchik claims that similarities in emotions extend over geographical and cultural borders, and even beyond the human species itself. Therefore, in terms of the PTM project, the physical expressions of emotion contained in silhouettes may, by the same premise, theoretically be recognisable universally, and through this, be useful as reference material for future development.

Plutchik's theory builds on scientific and intellectual traditions that Plutchik himself has described as; '...evolutionary (launched by Charles Darwin), psychophysiological (Wiliam James), neurological (Walter Cannon), and (in the) psychodynamic tradition (Sigmund Freud), in addition, to the cognitive perspective that began emerging in the 1950s' (Plutchik, 2001 p. 344). I do not see Plutchik's theory as a definitive answer on emotions; however, his theory provided a valuable scientific base for the project as well as introducing a colour scheme as a standardised approach for emotions visualisation.

It seems to be widely recognised that colours have a strong influence on human emotions and physiological bodily response. Blue-green colours can generate feelings of cold and red-orange colours can generate feelings of warmth. I believe that colours as representations of emotions appear to be applicable, and offer future potential as feedback systems for sensing devices. Within this research, Plutchik's models are adopted for colour tagging to represent the different emotions in the database and as conceptual and systematised visualisations of emotion as well as in the production of all the relevant charts and diagrams.

The poster: *Robert Plutchik's Psychoevolutionary Theory of Basic emotions* (Drever, 2007), provided a visual reference model for the research that explained Plutchik's Theory and invited new ideas for my own presentation of the accumulated data, as well as inspiring my own investigations into the visual aspects of emotion.

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3.2.5 The Resonance of Art

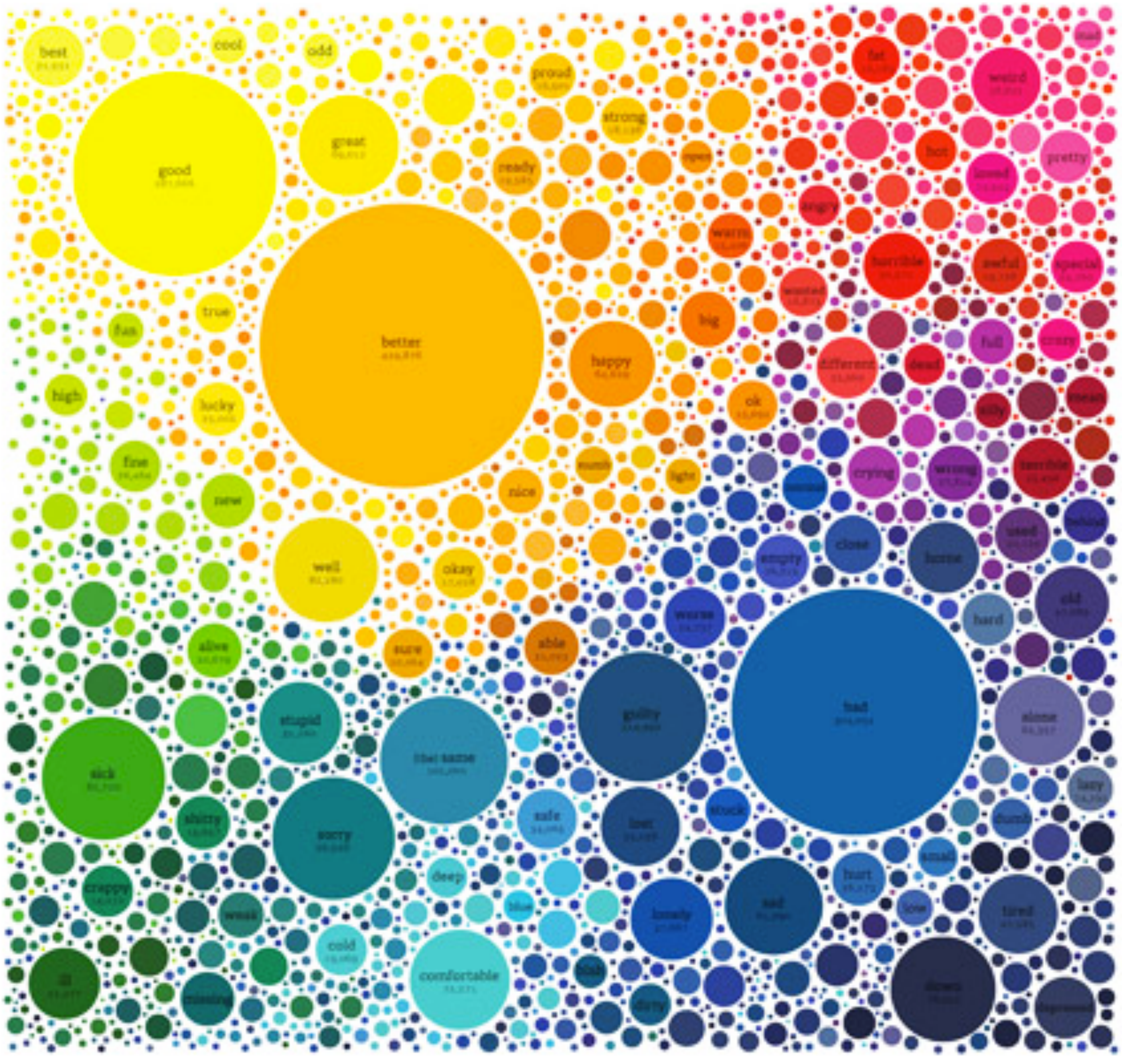

Figure 3.8 Top 2, 500 feelings, Kamvar and Harris, 2009, p. 236-237.

Plutchik's theory inspired several art applications based on his use of colours as metaphoric transcriptions of emotion. One of them, *We Feel Fine* (Kamvar and Harris, 2006) is an art research project build on a database of human feelings collected from texts written in personal blogs and builds on data collected over three years. The interactive application allows access to valuable statistics on the most expressed feelings, using classifiers such as gender, geography and time. The project is extremely well documented in the published book: *We Feel Fine: An Almanac of Human Emotion* (Kamvar and Harris, 2006), which explains all stages of the data collection process, from the idea to its execution. Additionally, their source code documentation was helpful in my investigation into a future database by providing information that connected colours, emotions and statistics. In figure 3.8 each circle is a feeling, including a scale to show how many times it was expressed from 2006-2009. Throughout the period of my investigations on colour, I wanted to determine the probability of Plutchik's (2001) colour associations coinciding with emotions, in support of his idea. This has been carried out through several surveys described in section *5.2.3.3 Analysis of the results for Colours and Emotions Questionnaire.* However, I have abandoned the additional surveys on colour, an experiment "on sight" when I discovered *Emotionally}Vague* (O'Brien, 2007), a research study by a graphic designer. Her research provided statistical data that partly confirmed Plutchik's allocation of colours to different emotions.

Figure 3.9 Joy, Research project; Emotionally}Vague, O'Brien, 2007.

Her research study, *How do you ask a stranger (not necessarily fluent in English*) *to recall and describe their private emotions?* (O'Brien, 2007), examined embodied and non-verbal qualities of emotions. Her final work consists of an extensive survey based on the answers of 250 men and women from over 35 countries. The research is presented as a visual emotional landscape based on five parameters; the placement of emotion in the body, the area that it originates from in the body, the direction of emotions, the colour associated with specific emotions, and the events that may provoke a certain emotion.

The emotions that she investigated were: anger, joy, fear, sadness and love. The study provided a large amount of data, which were visualised in different ways. The example in figure 3.9 illustrates joy as colour, text and consolidated drawings showing how participants feel the emotion in the body. The strength of the visually represented data provided a new dimension to my own research, introducing the graphical aspect of my own research material.
I found her research complementary to my own findings and have therefore implemented her visualisation method in my experiments with video-material and have compared her findings with my own.

My investigations into colour associations led me to a web-project, *Cymbolism* (Suffolk Software, 2008). The purpose of the project is to collect and quantify associations between colours and words with the support of visitors to the website, via a survey based on 19 colours. The feedback page is a vital part of the design, making it possible for the public to follow the results over time (figure 3.10).

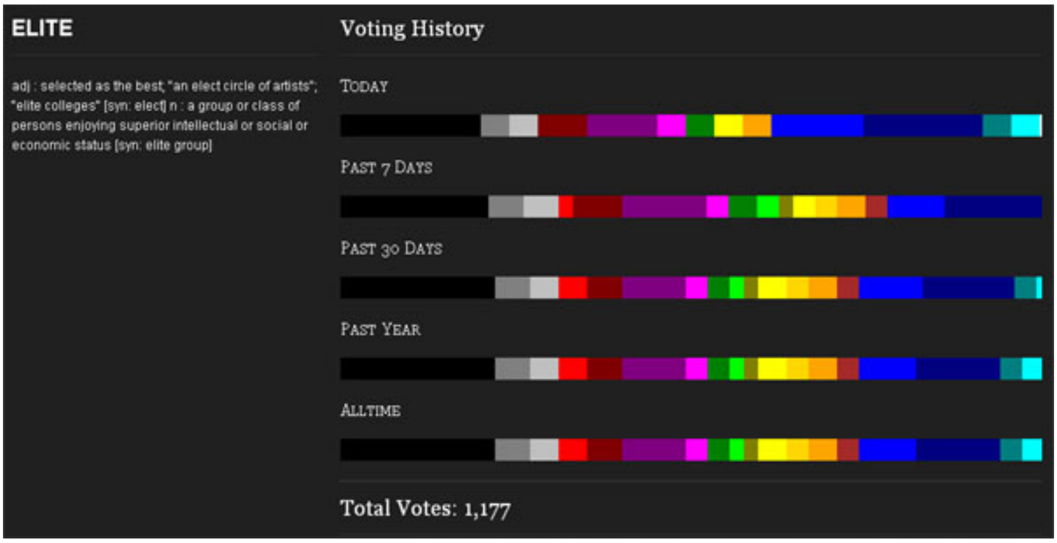

Figure 3.10 Voting History for emotions as colours, Cymbolism, 2008.

The results of the survey responses were enlightening, showing that colour associations did not change much over the period of the project, and providing the insight that timescales and trends do not greatly affect the way the international visitors of the website associate colours with emotions.

Another useful visualisation of emotions: *Colours in Culture* (McCandless, Doughty-White, Wdowski, 2009) is an infographic poster mapping the perception of colours of various cultures and presents statistical data in an accessible and aesthetic style. The poster visualises colours that correspond to eighty-four nouns, including emotions and correlated semantic expressions, such as strength, beauty and courage (figure 3.11). This work intensified the idea of viewing complex data as information visualisations, such as infographics, ideally to be used as tools of thought, extending cognitive processes by transforming abstract knowledge onto a map of ideas.

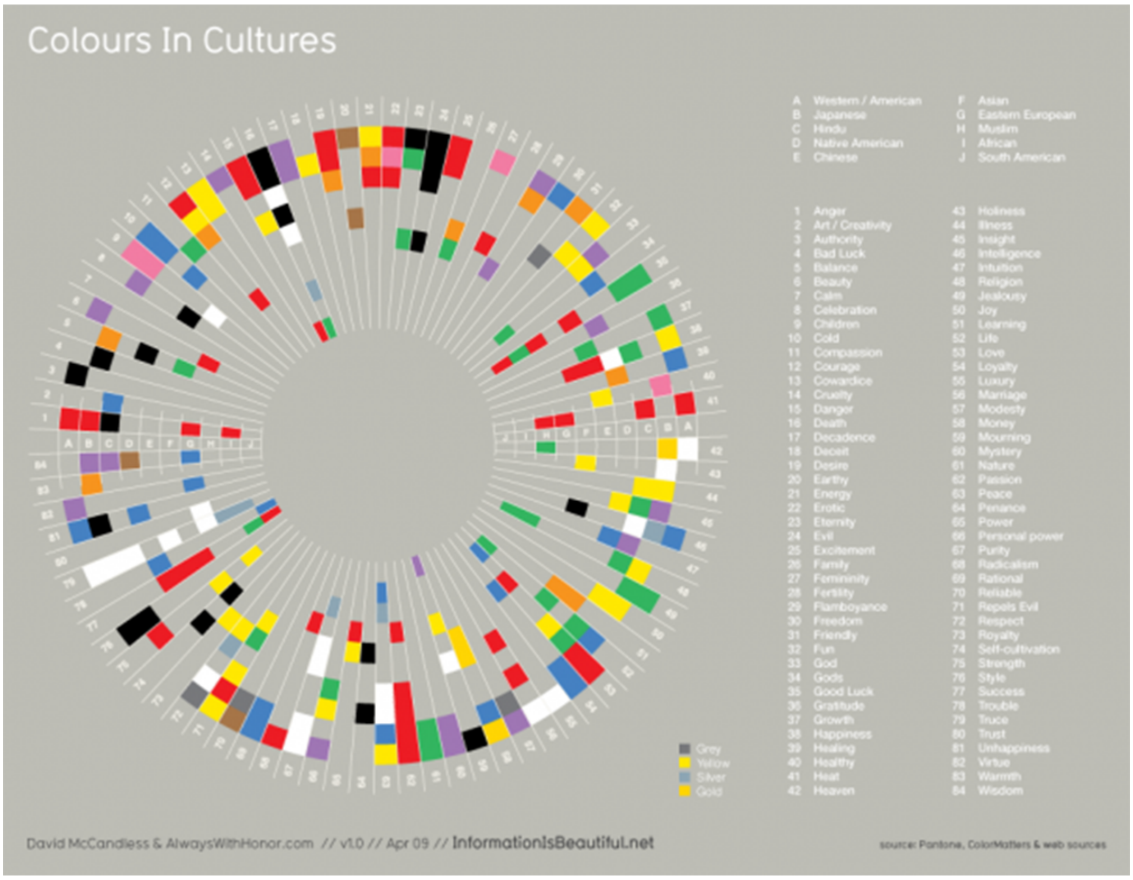

Figure 3.11 Colours in Culture, McCandless *et al.*, 2009.

Explorations of emotions in correlation with existing technology have contributed to several inspiring insights regarding the process of adequate data collection of emotions. *Bio Mapping device (Nolde, 2009)* is a technical solution that uses biometric data as an input, which he describes as:

> ... a portable and wearable tool recording data from two technologies: a simple biometric sensor measuring Galvanic Skin Response and a Global Positioning System (GPS). The bio-sensor, which is based on a lie-detector, measures changes in the sweat level of the wearer's fingers. The assumption is that these changes are an indication of 'emotional' intensity (Nold, 2009, p. 3).

Applying his ideas to PTM through the use of a biometric sensor during the recordings could augment the movement data by providing information based on more than just visual parameters. I propose that this could be used in future experiments, with the appropriate time and equipment. However, the fragility of the recordings, which would be compounded by additional wearable equipment, could be a negative psychological factor for participants in the research. However, Nold's project consists of more than biometric wearable technology.

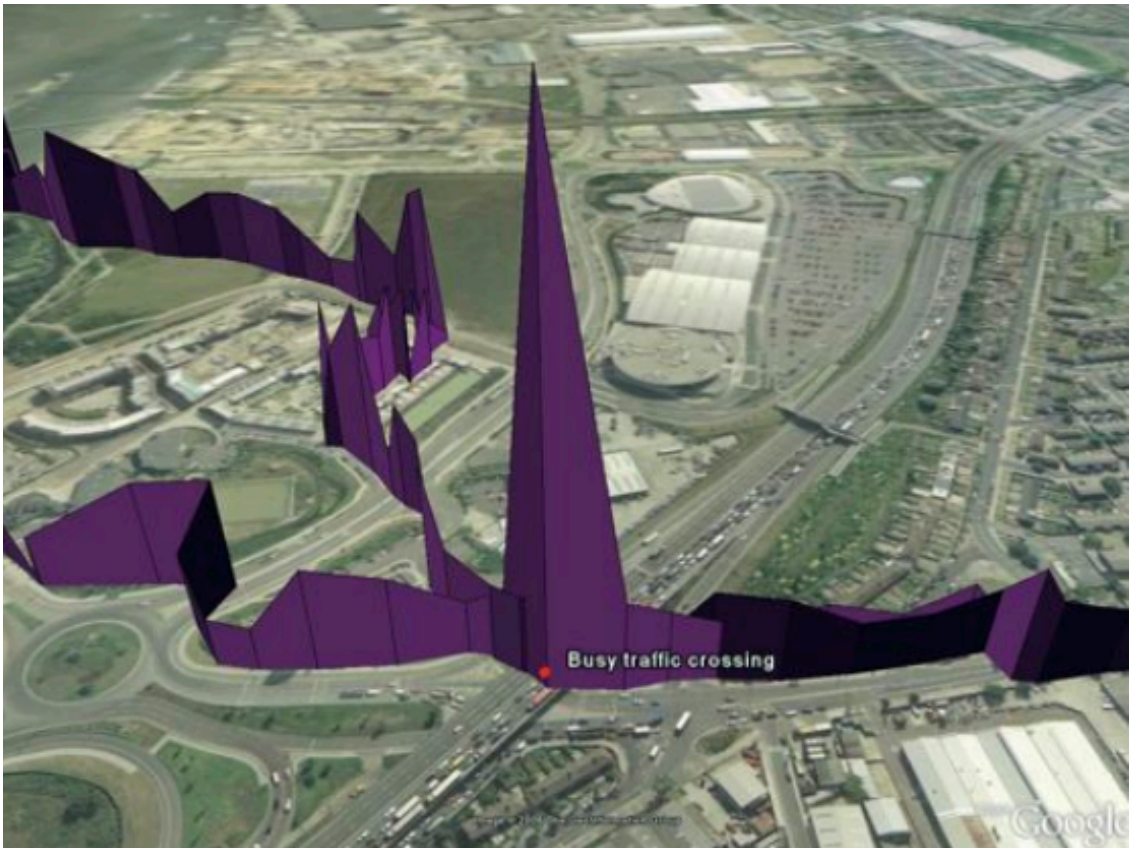

Figure 3.12 Bio mapping data shown in Google Earth, Nold, 2009.

Walks in the city are captured as data input and transformed to 3D visualisations as cartographical representations of participants' emotions reflected on a city map. Bio Mapping is a method of engaging people with their environment, which extends the body in the spatial-emotional dimension (Nold, 2009). For participants it is an interactive technique that creates an emotional response in terms of the body, space, movement and time and when these are transformed into 3D and applied to Google Maps, the result is visually impressive. The information landscapes are ubiquitously accessible promoting a novel form of participatory practices in urban spaces (figure 3.12).

3.2.6 Emotions in Virtual Worlds and Games Research

The issue of emotion in virtual worlds has been discussed by Bellman (2002), a psychologist and Principal Director of the Aerospace Integration Sciences Center. Her research interest is focused on "reflective architectures" that manage their own resources and adapt behaviours. In Bellman (2002) *Emotions: Meaningful mappings between the individual and its world*, she describes how emotions affect our evaluation of the world, including actions and decision making with an important question: ‘Why shouldn't we leave the topic alone as human-or at least animal-phenomenon, to be discussed by psychologists and physiologists but certainly not engineers and technologists?’ (Bellman, 2002, p. 150).

She highlights the importance of virtual worlds as possible test beds for research on emotional reasoning and emotional-selves. Based on research, Bellman (2002) placed emotion in a biological context: ‘Emotions are not only mappings between the world and the self, but rather they are in one sense the meanings of that worlds to the organism’. Furthermore, in the context of self-constructing autonomous systems she describes emotion as ‘critical to the formation of “self” in biological systems’ (Bellman 2002 p. 166) Similarly, in the context of virtual environments, according to Bellman “the self” provides part of functionality needed to adapt a distributed system to an environment’ (Bellman p. 171).

Both in the virtual and real worlds, emotion is an important factor in decision-making discussed and analysed by Bellman (2002) through the Multi-User Dimension (MUD) platform that allows an initial “ecology” or “physics” of the virtual world to be defined. The simulation abilities with well-specified environments provide the possibility of producing engineered models of abstract systems and their functions, which could be compared and evaluated empirically in virtual experimental laboratories. The virtual laboratory is a tool that could be used across the different disciplines, which is necessary in terms of research on emotions and its relation to perception of the self (Bellman, 2002). She summarises her assessment as follws:

> This will not only build better systems to serve us, but also build systems that can more effectively and naturally include us as part of the systems….this starts moving us toward the development of a more “livable” technology (Bellman, 2002 p. 185).

Emotions are investigated in games research from the perspective of narrative potential, where the emotional characteristics of characters are essential to the game design. Drawing on the idea of emotions as modules in agent structures, Eladhari's (2011) research; *Characterising Action Potential in Virtual Game Worlds Applied With the Mind Module,* provides an example of semiautonomous agent structures via the experimental prototypes of mind modules in Artificial Intelligence (AI) based game design. She is a game researcher at The Institute of Digital Games at the University of Malta. She is also affiliated with The Expressive Intelligence Studio at the University of California SC, and with The International Research School of Game Design at Uppsala University. The focal point of her research is on emotions and moods as part of the narrative system in games. The objective of her research on mind modules is to provide players with tools for the design and control of game characters. The term 'mood' is used in terms of the personality of playable characters (PC) in the mind modules' set where control over the structure of agents is shared between the system and the player.

The mind modules that contain the personality of game characters are a collection of traits that are maintained, as Eladhari (2011) describes: '...dynamic emotional state as a function of interactions with objects in the environment, and summarises a PC's current emotional state in terms of mood' (Eladhari, 2011, p. iv). The mind modules build a 'spreading- activation network of affect nodes that are in relation to each other and interconnected divided in; personality trait nodes, emotion nodes, mood nodes, and sentiment nodes' (Eladhari, 2011, p. iv). This construct provides relationships between the game characters that can be designed and controlled by the player. It is an example of a structure that opens the possibility for players to have bodily-based interactions, where emotions could be defined via expressive movements. Using optical recognition devices such as Kinect (Microsoft, 2010), whole body movement and gesture could be involved in the creation of the narrative, becoming a potential source of creativity in games. In this way, the issue of playability could be extended to somatic experience utilising the interdependence between emotion and cognition.

3.2.7 Conclusions

Summarising research findings from the previous section I make several assumptions necessary for the design of the database. Despite the controversy about scientific evidence for how emotions are executed in terms of body and cognition, an assumption has been made based on previous research. Mainly, that human emotional expression and visual perception are superior cognitive processes (Darwin, 1872; Damasio, 1994; Havas *et al*., 2010; Plutchik, 2001; Prinz, 2004; Altarriba *et al*., 2003; Merleau-Ponty, 1962). Emotions are subjective and developed over a long evolutionary process in the context of survival and social environment. Emotive expressions are patterns of bodily changes, and used as communication tools (Plutchik, 2001; Preston and de Wall, 2002; Bellman, 2002) and conditioned by the socio-cultural environment (Lutz, 1986; Mauss, 1979/1934). Emotions have reversible actions since facial expressions; body movements postures and gestures can provoke emotions. (Darwin, 1872; Damasio, 1994; Havas *et al*., 2010). Extensive research has been carried out in the field of recognition of facial expressions. However, the amount of work on the recognition of emotional expressions of the whole-body is relatively small.

The research findings established on visual perception of facial expressions of emotions and similarities in linguistics reviewed in reference to previous research by Altarriba *et al.* (2003) and Prinz (2004) conclude that there is a large degree of universality among six basic emotions; happiness, surprise, fear, sadness, anger and disgust, enhancing the evolutionary view and Plutchik's theory of emotions.

The issue of the communicative aspects of embodied emotion is discussed in the context of phenomenology and especially in terms of relationality, i.e. from the perspective of 'the other'. The interpersonal exchange of body language is defined by Merleau-Ponty (1962) as “inter-corporeality” which van Manen (1990) explains as the “lived other” (relationality) that is always in co-existence with the other two “lived worlds”: “spatiality” and “temporality”.

The visual communicative aspects of expressions as tools for communication were taken into consideration in the database design, supported by an online survey where the readability of silhouettes in motion was measured. The data collected and evaluated provided visual charts as indicators of the communicative qualities of expressions for each documented emotion, actor and video clip.

In terms of colour as a tool for the visual concept of emotion, I applied Plutchik's (1980) metaphor of emotions as a schematic visual concept of emotion. Plutchik's use of colours for the description of emotions is based on analogue and complementary colours and their combinations in the classic colour wheel, used by him as an analytic tool to present his idea of eight basic emotions and correlated secondary emotions. Similarly, O'Brien's (2007) study based on emotions perceived as colours provide both inspirations to my working process as well as qualitative data from her investigation. Grounded in the similarities among colours used to visualise emotion among the examples investigated, through art, science and design, I use the same schematic colour combination throughout the study. Namely, a standard colour combination is applied to the description of emotions in the database tagging system and the visualisations of emotion data; red for anger, green for fear, yellow for joy and blue for sadness. Discussions on emotions versus cognition are an ongoing process in science, art and game design, where cross-disciplinary research is often required. In this context, Bellman (2002) highlights the importance of emotions in the development of artificial intelligence (AI) agents in virtual worlds, proposing virtual experimental laboratories as test beds for research on emotional reasoning. In general, these findings suggest that more research is needed on emotions in virtual environments as well as research on the visual perception of emotions as whole body movements.

The findings based on the contextual research have simplified my working process by providing a stable grounding for the database design. This has been acheived in the context of the emotions chosen, the schematic colour tagging system and the visualisation of communicative properties of emotion.

These assumptions and findings are transferred to the investigations and discussions in section 3.3 *Movement, Body, Art and Technology*. There, the emotions are discussed in the context of embodied performative expressions, presence in the body and particularly the reversibility of embodied expressions. The issue is investigated in the context of performance art as well as in relation to movement recognition technology and game development research.

3.3 Movements, Body, Art and Technology

The Nervous System thinks in terms of movements not muscles.
- Sir Charles Sherrington (Nobel Lecture, December 12, 1932)

This section is an attempt to summarise the paths taken by me both during my earlier research, *Mapping motion* (Hrynczenko, 2009b), as well as when I was looking more closely at technological developments in relation to the body and physical movement during the contextual investigations.

These are divided into several parts; section 3.3.1 *Threshold of Presence and Space* investigates inner and outer space as key factors influencing movement. Section 3.3.2 *Body in Motion in Timeline and Space* is a journey from past to contemporary times which investigates the issue of visual registrations of body movement, movement aesthetics and its visual representations. Section 3.3.3 *Emotions and Movement: Expressionist Dance* contextualises Von Laban's philosophy in the historical perspective of early twentieth century and German Expressionist Dance. Section 3.3.4 *Silhouettes and Expressive Movement* describes silhouettes as a visualisation method. Sections 3.3.5*, Body, Movement and Technology,* 3.3.6 *Technology; Perceptual Interfaces and Movement Recognition*, 3.3.7 *Movement Recognition Technology and Art*, 3.3.8 *Digital Space From The Performer's Perspective* map the areas of technology and performance art that explore human corporeality in movement.

My purpose here is to make connections between past and contemporary ideas in order to discuss new technology that is compatible with the ethos of embodied practices in the areas of dance and performance art in relation to technological advancement. Section 3.3.9 *Physical Body, Emotions and Games* is a review of the research that focuses on physical movement in the area of games development. The most important findings from all sections are summarised in section 3.3.10 *Conclusions*.

3.3.1 Threshold of Presence and Space

> *According to Phenomenology, 'kinesthetic sensations' forms an essential part of the constitution of our spatiality, occurring as a result of–and continuously impacted by–our physical experience and our conscious and unconscious interpretation of that experience (Kaylo, 2003, p. 2).*

A study of somatics and kinetics of movement and movement consciousness has significant implications for the analysis of physical movement in all digital practices, especially methods that have been proven to augment *kinaesthetic perception* in dance and theatre, i.e. the embodied awareness on stage. The presence in the body correlates with the presence in space, real or virtual, aggregated in the present moment. Nicolescu (1985/2001, unpaged) describes the present moment in relation to performance by referring to Peirce's definition of the *present moment*: 'There is something primitive, direct and immediate in the idea of "present moment", a sort of absolute liberty in relation to performance, a revivifying sentient spontaneity' (Nicolescu 1985/2001, unpaged). Furthermore, according to Peirce (via Nicolescu, 1985/2001, unpaged); 'The idea of present moment, within which, whether it exists or not, one naturally thinks of a point in time when no thought can take place, when no detail can be differentiated, is an idea of Primacy…'. Here Peirce refers to, primacy as '…the mode of being of whatever is such as it is, in a positive way, with no reference to anything else at all' (Peirce via Nicolescu 1985/2001, unpaged).

Underlying my investigation is an interest in the authenticity of movements in relation to the presence of the performer in their body. During the expressive movement documentation process, certain questions have arisen that provoke reflections on historical and theoretical detours of presence, the human body and space; therefore contemporary dance and performance studies were my first choice in terms of contextual research.

In Lepecki (2004) *Of the Presence of the Body*, he presents an anthology of essays that critically evaluate two central concepts; the notions of "presence" and "body" as they are shaped and reshaped in social and historical circumstances, forming a theoretical base for performance practices. Historically, in western culture, "presence" and the "body" have been discussed in dance and performance theories since the beginning of the 1960s, partly provoked by a need to narrow the concepts of performativity, in connection to sociological and political theories formed by this critical theory in the performing arts.

> One may say that dance emerges as a critical theory precisely from its uncanny foregrounding of the split between body and presence. One may even add that dance as critical praxis may draw its force precisely by a creative, if not altogether subversive, occupation of this gap (Lepecki, 2004, p. 3).

In one of the essays, Burt (in Lepecki ,2004) discusses influential work on the tension between the physicality of the body on the stage and notions of the subject and its presence. He highlights through the analysis of studies on dance and choreography the influences by feminist theory, gender studies, and comparative analysis in Yvonne Rainer's *Trio A* (Rainer, 1965), Pina Bausch *Café Muller* (Bausch, 1978), and Anne Teresa de Keersmaeker's *Rosas Danst Rosas* (De Keersmaeker, 1983) against a background of post-constructivist theories. These performances were important in my early confrontations with contemporary dance, where I perceived them as a sign of a dialogue between the dancers and the body, which slowly unfolded in the dance scenes as discursive practices in 'constituting subjectivity' (Foucault, 1961). Not unaffected by philosophical trends, I was then preoccupied by transformations from physical theatre into *Butoh*; the issue of 'of/on' the body and the presence in the body occupied part of my time, not however as a philosophical discourse but rather as on an almost biological and physical level. Therefore, the analysis of this period of time as well as the issue of presence from a philosophical and political perspective provides an extended view of the factors that underlie my own research. These are reflected in artistic practice and situated within a contemporary cultural context within which I operate today, turning my attention to the politics of culture, identity, gender and representation.

In order to widen the study beyond the performance stage, I have looked at the issue of embodiment from different perspectives. In *Towards a Science of Embodiment,* Mazzola *et al.* (2012) a mathematician and music theorist discusses core issues of embodiment from the scientific perspective related to semiotics. As a multilingual person, I pay attention to the symbolic value of language and its cognitive aspects. As a result, I found that the issues discussed in this document are significant in the context of presence. Looking at embodiment from the perspective of semiotics, Violi, an Italian linguist, pointed out the paradox in which 'on one hand there is a theory of embodiment without subject, on the other a theory of the subject without a body.' (Violi via

Mazzola *et al.,* 2012, p. 67). His comments on this statement conclude that ‘this is a gate to the problem of why embodiment is such a basic category of any type of articulation, verbal and beyond’ (Mazzola *et al.*, 2012, p. 67). In relation to the present, both statements provide a broader perspective on the cognitive dilemma that is rooted across human expressions.

When analysing the theorem of presence in a historical context some cross-referencing is required in terms of body-centred knowledge and practice, for example Gurdjieff (1866 –1949), due to the influential value of his cosmology, methods and techniques that has contributed to the development of modern performance methods.
Gurdjieff's work, known as *The Fourth Way*, or the *Gurdjieff Teachings* (Ouspensky and Gurdjieff, 1957*)*, represents a collision of western scientific and psychological ideas with eastern mysticism that are still explored today, being reinforced through ideas of psychophysical acting techniques and showing analogies with current trends in psychotherapy and psychology (Cescato, 2008).
The concept of emotions as being integrated into body movement was reflected in his teachings, on both theoretical and practical levels, as a set of actions that activate certain emotions or states of mind (Azize, 2012). These movements have the purpose of strengthening distinct centres, explained in his *Theory of Seven Centres* (Gurdjieff, 1933) where the emotional centre is one of the three main centres; intellectual, emotional and physical. These three brains, or “centres,” as Gurdjieff called them, were often out of harmony with one another.

> Man cannot be master of himself, for not only does he not control these centres,
> Man cannot be master of himself, for not only does he not control these centres,
> which ought to function in complete subordination to his consciousness, but he does not even know which of his centres governs them all. (Gurdjieff, 1933, p. 30)

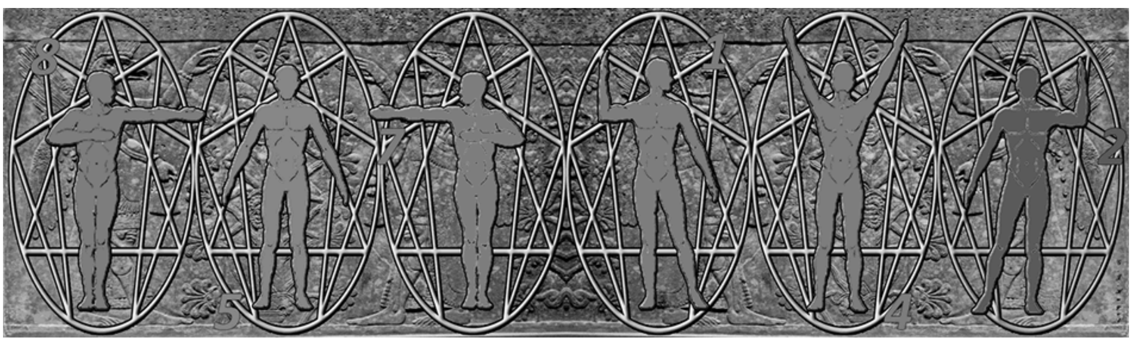

Figure 3.13 Gurdjieff’s Enneagram Movements, Inscapes, 2013.

Figure 3.13 illustrates movements based on an enneagram inspired by sacral dances from Egypt, which refers to body and movements' geometry, an idea that was explored further by Rudolf von Laban (1879–1958) that is analysed in section 3.3.2 *Body in Motion in Timeline and Space.*

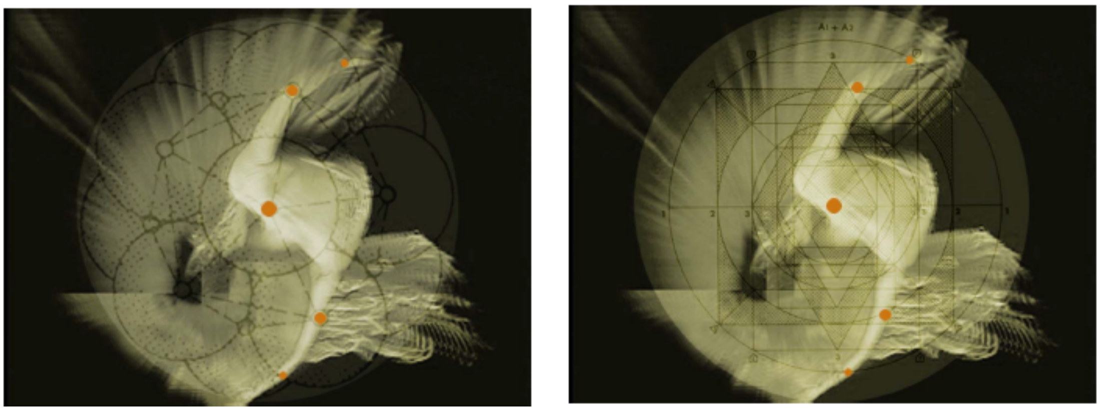

Figure 3.14 Geometric patterns of body in movement, Hrynczenko, 2009.

Figure 3.14 represent geometrical forms inspired from nature overlaid on the body and movement in the context of corporeal geometry and kinesiology and is one of my previous experiments on movement and geometry. Gurdjieff's ideas have had some influence on my own development, yet the process has been subconscious, since I came in contact with his theories at an early age through my parents, who were active practitioners of his movements and teachings. Conceivably, my own attitudes to the physicality of the body and self-observation came from that source, contributing to notions of presence and consciousness of the real world. The concept of *inside* and *outside* began to crystallise, consequently formed by exercises developed during Grotowski's workshops, and finally during my work with *Butoh*, to take a unified form.

Gurdjieff, known to the western world more as a mystic and epicurean philosopher than scientist, in fact devoted a great deal of time to psychological and ethnographical studies. Inspired by dance and movement practices during his journeys to the Near and Middle East, Asia, India and Africa (Egypt) he adapted the knowledge he accumulated from traditional dance movements by combining them with techniques directly related to the development and training of attention. Oksanen (2006) describes Gurdjieff's movements according to names that refer to 'Obligatories'.

> There are different series of movements, starting with the six 'Obligatories'. There is a second series of obligatories, Tibetan dances, Pythagorean dances,

> Greek movements, dervish dances, dances based on the Enneagram, rituals, special women's movements, work movements, prayer movements and others (Oksanen, 2006, p. 1).

In the present form these movements are known as *Gurdjieff's Sacred Dances*, and were inspired by Dervish dances serving as self-study exercises (Challenger, 2002, pp. 13-15), which activate perception, physiological arousal and emotion. Gurdjieff'*s* movement techniques were inspirational in both Western and Eastern Europe and his teaching and ideas were as significant for performance art as they were for Konstantin Stanislavsky (1863-1938), Peter Brook (b. 1925), Jean-Claude Carrière (b. 1931), Eugenio Barba (b. 1936) and Jerzy Grotowski (1933-1999). Gurdjieff'*s* practice was reflected in some of the techniques used in physical theatre (Brook, *et al*., 2001). These connections revealed a depth of ideas and pointed to a need for the restoration of ancient methods in performance art towards the end of the last century, as manifested in the work of Barba, Brook, Carrière, and Grotowski (Brook, *et al*., 2001; Barba and Savarese, 1991).

As a starting-point, during the expressive movement recording sessions, described in section 4.3 *Emotions/Movement Documentation Process* I applied several of Gurdjieff's techniques that helped performing participants to centre their bodies to embody their presence. One of these techniques was movement repetition. The repetition of movement is a supplementary technique used by Gurdjieff in his school of dance and I adopted it when developing *Shadow Dance* (Hrynczenko, 2009a) an interactive application in real-time. The idea of repeated movement, among other methods (revealed in Appendix P: *Workshops*), was used with students during the workshops, as well as before every documentation process. The approach was intended to provoke a spontaneous, creative movement and contribute to a relaxed atmosphere. The recording sessions would then provide a vehicle for participants to centre their attention on the body. During the development of *Shadow Dance*, I focused specifically on rhythmic paradoxes as a key to awareness, through action of attention (Cohen, *et al.,* 2008). According to Gurdjieff's (1920, p. 181) own explanation, the aim of his movements was to serve the '…harmonious development of man by a method of combining mind and feeling with the movements of the body, and manifesting them together...interprets the whole man: mind, body and feeling'.

In the context of presence, I refer to Stanislavsky's approach to physical, performed movements. His interpretation of Gurdjieff's self-reflection of insight and outside is that he cleaves the performer into two kinds of personalities; '… I divided myself, as it were, into two personalities.

In the context of presence, I refer to Stanislavsky's approach to physical, performed movements. His interpretation of Gurdjieff's self-reflection of inside and outside is that he splits the performer into two kinds of personalities;

> …I divided myself, as it were, into two personalities. One continued as an actor, the other was an observer. Strangely enough, this duality not only did not impede, it actually promoted my creative work. It encouraged and lent impetus to it.' (Stanislavsky 1968 p. 21).

On the contrary, *Butoh* dance is based on balance, a self-directed movement process attempting to find a natural body through transformative imagery. Butoh's aesthetics provoke a primal and mythological presence, as they are not divided between a controlling and a controlled side. The performer balances in two kinds of time, inside and outside (Maro, 2005).

Performative techniques worth mentioning and exploring in the context of emotions and the notion of presence include Mary Starks Whitehouse's (1911- 979) Authentic Movement, an idea developed from Mary Wigman (1886 - 1973) and Martha Graham (1894 -1991) based on Jungian methods. Noteworthy also is the Alba emoting technique (Bloch, 1995), developed by neuroscientist Dr. Susana Bloch, with the purpose of releasing and guiding emotional states, as well as the eurhythmic methods of Émile Jaques-Dalcroze (1865 - 1950). The performative techniques could be used in order to develop specific movement schemes coordinated with game narratives. However, in the scope of this contextual research I found it important to focus on techniques that were implemented during practice-based research, leaving other correlations for future investigations.

From a phenomenological perspective, Kozel's (2007) discussions in her book *Closer* range widely across the presence of the human body in the technological space that she worked from. Her reflections on motion capture technology, not just as a tool for artistic expressions but as explorations of presence and space in relation to others, have increased the philosophical layer of my outlook, and understanding of the interplay with technology. She refers to Merleau-Ponty's dynamics of reversibility, conceiving that ‘performance involves the awareness of being in a state of reception and initiation between inside and outside, modulation and response’ (Kozel 2007, p. 70).

> When we perform we mediate inner and outer; we translate; we regulate; we discover; we get surprised, angry, fearful, hurt and exhilarated. If we create responsive relations with others and our environments, relations that transcend language, then by means of intentional performance with technologies we can regard technologies not as tools, but as filters or membranes for our encounters with others (Kozel, 2007, p. 70).

In the context of my own documentation process, Kozels literary “acting the phenomenology” provides methods for reflections.
Kozel refers to Dennett’s (1991) concept of ‘phenomenology of another not oneself’ coined by him as ‘heterophenomenology’, which has implications on the expressive movement documentation process and movement analyses, explaining the dual roles of the researcher. Her in-depth analyses and interpretations of Merleau-Ponty's philosophical view of human perception through the body and her practice-based methods capture the essence of basic human values in digital space.

> Physicality is the basis for understanding and negotiating digital abstractions, both virtual and otherwise, and technologically mediated experimentation allows us to expand upon the phenomenon of embodiment (Kozel, 2007, p. 108).

I regularly work with students. In order to find tools and methods that may assist an untrained performer and act as a platform to build upon during the documentation process, I shifted to the concept of ritual as a mode of perception and transformation. In my investigation, I tried to find common denominators from various methods of dance and performance, unified by a perspective of “being in the body” as being in the “absolute space”. In addition, I have connected this view with Kozel's phenomenological methods.

However, my idea of using ritual as a method in part originates from Grotowski's meaning of the theatre itself; the theatrical ritual is a tool, and specifically the idea of the sanctity of the performance space, through the actor. More controversially, as a way of gaining a holistic view, and inspired by Schlemmer's drawings (1921, 1924, 1928a), I was searching for liminality, where the sanctity of the performance space is an extension of the sanctity of the performer's body (Gurdjieff, 1933; Grotowski, 1968; Kozel, 2007) through the inherited memory of movement or as resonance of what could be the symbolic interpretation of emotions. This idea could be unified by what Lefebvre (via Yarrow and Chamberlain, 2007) describes as a "phenomenology of absolute space" which applies to the idea of primal existence as unity of the inside and outside, beyond cognitive controlling factors. This is linked to my experience with *Butoh*.

> Here and there, in every society, absolute space assumes meanings addressed not to the intellect, but to the body, meanings conveyed by threats, by sanctions by a continual putting-to-the-test of emotions. This space is 'lived' rather than conveyed… Considered in itself - 'absolutely' - absolute space is located nowhere. It has no place because it embodies all places, and has a strictly symbolic existence (Lefebvre via Yarrow and Chamberlain, 2007, p. 186).

The significant factor that connects the issue of presence and the symbolic and imaginary space with a 'believable' acting of emotions is the playability of fiction, which needs further contextualisation in terms of playfulness and play. Schechner (1993) in *The Future of Ritual: Writings on Culture and Performance*, uses the human ability to play as a mode of perception crucial to transformative potential:

> Performance's subject [is] transformation: the startling ability of human beings to create themselves, to change, to become—for worse or better—what they ordinarily are not (Schechner, 1993, p. 1).

These are ideas that also seem to be applicable to representations of a virtual landscape as an experience or as a mode of perception.
According to (Huizinga, 1955, p. 10), any place can become a playground when a set of rules are introduced, which creates 'Temporary worlds within the ordinary world, dedicated to the performance of an act apart'. A state of perception, coined by Huizinga as a "magic circle," metaphorically describes the characteristics of play based on the idea that, when the rules and the agreement about them enter the space of the playground, the participants become part of a separate space, which they share under playful conditions.

These characteristics theoretically constitute the boundaries of the game. Similarly, in convergence with games, Schechner (2003) pointed out the social function of a performance, which he related to the possibility of elaboration with rules. According to Schechner there are rules that apply to activities such as games, sports, theatre, and rituals that last since these refer to activities that are separated from real life. He points out: '... a special world is created where people can make the rules, rearrange time, assign value to things, and work for pleasure' (Schechner, 2003, p.13).

During the documentation process, playful rituals became springboards into the participants' own creativity and adeptness at first getting in touch with, and then interrelating and performing emotions. During the recording of expressive movement, it was important to provide the participants with tools that enabled insight to their bodies, in order to draw on emotions beyond their analytic intellectual reasoning.

3.3.2 Body in Motion in Timeline and Space

> *Science tell us that motion is an essential of existence…Motion becomes movement in living beings, who possess an inner urge to use time and the changes that occur in time for their own purposes (Vetter, 2010, p. 99).*

Considering the notion of presence, I have been searching for deeper relationships between physical movement and emotional expression to determine what causes authenticity of movements and whether it is possible to express a performer's presence via visual patterns. This section contains some of my reflections from my contextual research *Mapping Motion* (Hrynczenko, 2009b), which I found important when reconstructing the final thesis as a reference in terms of influences on the development of ideas, on my working process, and on the methods used during the research. The influences of early mechanical images, such as the works of Muybridge (1830 -1904), Marey (1830 -1904) and chronophotography, are visible in the modified techniques I have used as supplementary visual data, in an attempt to bridge time and movement. Muybridge's and Marey's mechanical images were both revolutionary and revelatory, providing insight into what previously couldn't be observed with the human eye. Movement traces leave an imprint of the body on a timeline, extending the perception of movement in a different manner from that which we are used to, and allowing us to connect movement sequences through time in a visible dimension.
In practice, during the movement visualisations process, the movement in the video material collected was translated into frames and superimposed in six layers into *Chronophotographic Charts*, used for data analyses. This turned out to be a useful method when searching for similarities in expressions of specific emotions during the triangulation process. With this in mind, and in the context of this project, I will use the term "reinventing", due to the fact that I am moving a few steps back in terms of technical inventions.

Figure 3.15 Animal locomotion; Plate 519 Volume: Vol. II. : Males (nude), Muybridge, 1887a.

The work of Muybridge and Marey was inspirational during the first iteration of the research for *Mapping Motion* (Hrynczenko, 2009b), bridging the technical inventions of the past with those of the future. Muybridge's documentation of movement in relation to time exemplified in figure 3.15 with excerpts from the series *Animal Locomotion* (Muybridge, 1887) becomes significant for the anthropology of movement in general.

It influenced the work of the Futurists as well as other individual artists, for example as reflected in the work *Nude Descending a Staircase, No. 2* (Duchamp, 1912). I share Muybridge's interest for collecting movements and find his work interesting as an inspiration for a database as an art concept. Similarly, the studies on motion by Etienne-Jules Marey (1830 -1904) have left its trace on my research. His work on the nature of movement is particularly interesting in terms of his early inventions that provided tools for motion mapping (figure 3.16). His sequential studies of movement with the use of on-body contrasting markers on limbs and joints are precursors to motion capture technology. His two-dimensional graphical photographs engage the viewer in movement representations in the third dimension with depth replaced by time, enabling the viewer an almost physical feeling of movement (Hrynczenko, 2009b).

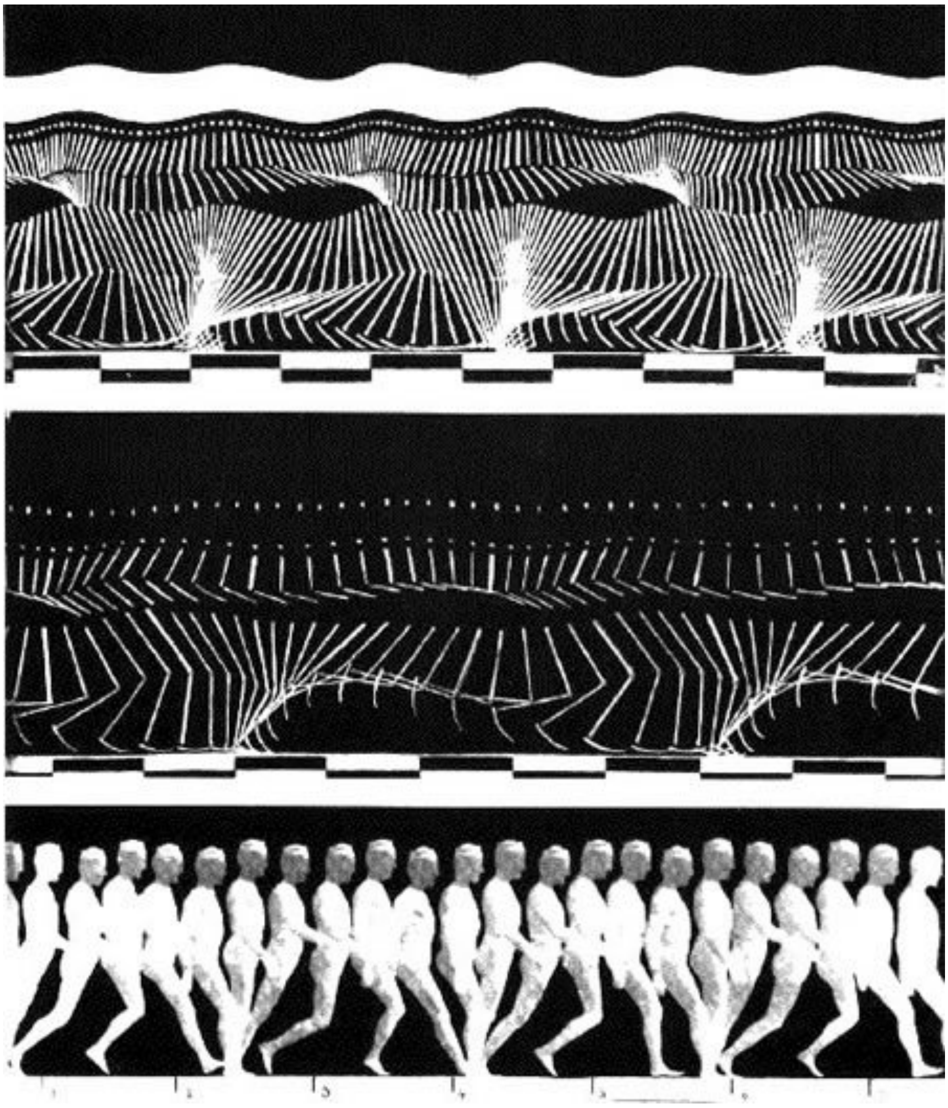
Figure 3.16 Chronophotographs, The Human Body in Action, Marey, 1870.

The result of these explorations of physical movements, navigable through visual representations and physical motion, is represented in *Shadow Dance* (Hrynczenko, 2009a), which also works as an evaluation of silhouettes as the final output.

The concept of silhouettes as an aesthetic experience and inspiration is connected with several sources, going back to my early teenage years in the late 1960s. At that time, I was fascinated with *The Seventh Seal* (Bergman, 1957) and had the film poster on my wall (figure 3.17). The poster shows the silhouettes of travelling theatre actors that along with some others are walking in a single line on the way to the last performance. Led by Death, they are a symbolic representation of the diversity of human characters and their existential struggle. The silhouette format amplified my imagination, enabling me to “perform” their parts in my imagination one by one, just by analysing their postures. As if the missing part of their facial expression was an opening, the silhouettes provided an invitation to form my own interpretations, enabling the possibility for improvisation. No more than a memory recollection, this is nevertheless important, not only for the paths my life has taken, but also for my present motives and choices during this research.

Figure 3.17 Poster, The Seventh Seal, Bergman 1957.

In the context of movements and its representations in film, art and animation, I have chosen to refer to dance on-screen and its pioneer, Maya Deren (1917-1961) particularly in terms of movement repetition on screen. Connecting with her interest in time, explored through her editing techniques, she introduced a surrealistic concept of time and new ideas of composition, extending the concept of movement sequences in early dance film. An example of dance choreography edited by her during the postproduction process is shown in figure 3.18 and illustrates a screenshot from her last creation *The Very Eye of Night* (Deren, 1958). In this experimental film, dancers' silhouettes, shown in photographic negative, are in juxtaposition to nocturnal space in which Deren exposes dance as movement in space and without a focus on the narrative.

Figure 3.18 The Very Eye of Night, Deren, 1958.

The repetition of movement and form has often been the subject of my own interest; a fascinating convergence between nature and architecture. When movement and form flow into the rhythm, the repetition of motion creates a trace both on-screen and in the body's memory. This idea is reflected in visual representations as the main part of the database, as well as in additional tools developed as support for the workshops.

A different approach to understanding movement and time are movement notations that take into consideration body movements in relation to space and movement volume. We articulate our bodies through both space and time, and this is fundamental to the nature of movement notations ranging from the Baroque era to today.
The examples shown in figure 3.19 provide an overview of the differences in dance notation; the Beauchamp-Feuillet notation (1700); Alphabet du Corps Humain, (Stepanov, 1892); Labanotation by Laban developed between 1879 –1958 (Hutchinson, 1954); Choreology, a dance notation invented by Joan and Rudolf Benesh in the 1940s (Benesh and Benesh, 1956) and Eshkol-Wachmann notation of 1958 (Eshkol and Wachmann, 1958).

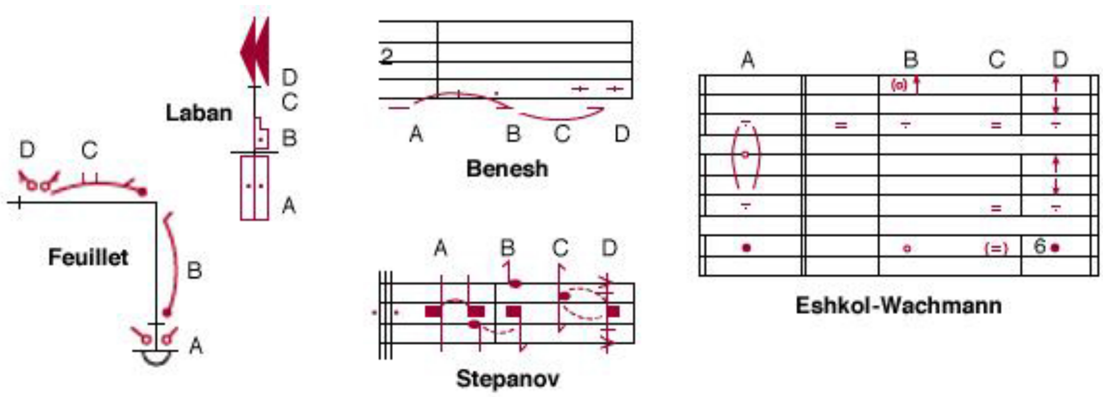

Figure 3.19 Dance notations, Encyclopaedia Britannica, 2006.

These concepts of movement registrations as symbolic values of the body-in-motion all differ from each other as shown in the five systems of dance notations previously described (figure 3.19). Interestingly, these notations all illustrate the same body movement. According to the Encyclopaedia Britannica (2006) point ‘(A) is a starting position: stand with feet together. (B) Step forward on the right foot (count 1). (C) Land to the left, feet together, knees bent (count 2)’.

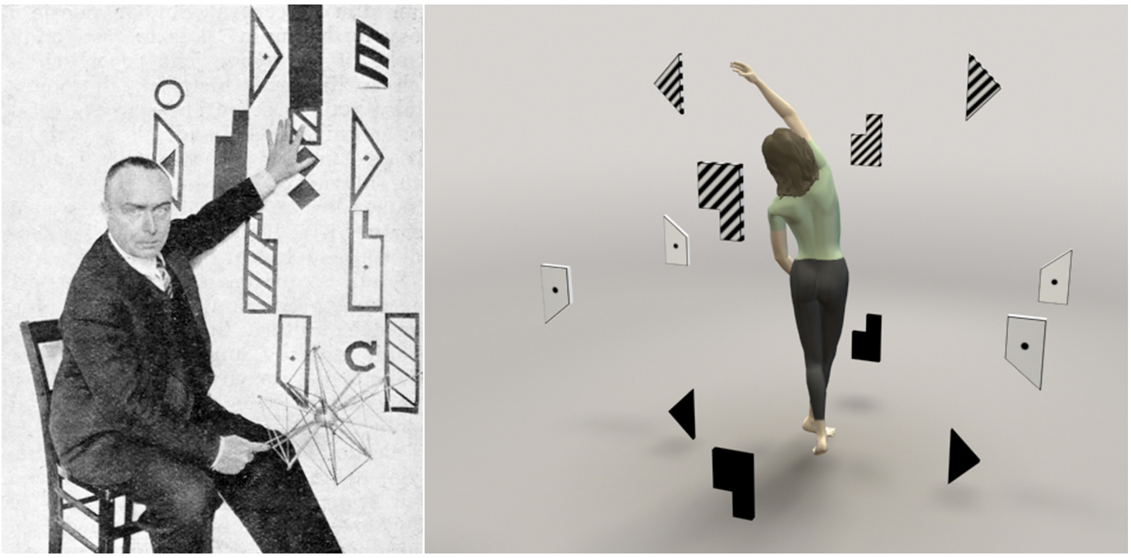

Figure 3.20 Laban and Labanotation, 1929 (left); notation in 3D, (right), Interdisciplinary Collaborations, (2012).

Rudolf von Laban (1879–1958), choreographer, dancer, and theorist created a system that allows the notation and analysis of movement: Labanotation, which is the most well-known type of dance notation, describes the moving body in terms of time, space, effort, flow, shape, and direction (figure 3.20). Labanotation, also occasionally referred to as Kinetography Laban, is based on the Laban Movement Analysis (LMA) system that encompasses the ontology of movement descriptions (Hutchinson, 1954).

Laban was inspired by the most natural forms of dance and translated them using geometric notation as taught by stretching or bending the body to fit within a given space; he reintroduced the ideals of ancient Greek physical culture and art at the beginning of the 20th century. As a part of the preparation process, during the DAMA workshops and the emotive movements' documentation, I used movement exercises based on Gurdjieff's Sacred Dances that build on the similar principles of movement and geometrical structures that originates from ancient Greek and Egyptian cultures. Laban, similarly to Gurdjieff by whom he was influenced (Kolb, 2009), refers to human predisposition to multidimensionality in his Tänzeerischer Sinn the "dancery sense," with the explanation: 'This perception of the dancer unites the whole sensual, emotional and intellectual perception under one entity' (Laban, 1920, p. 134). This thought characterizes the LMA system and Labanotation that is built on three-dimensional geometry and is connected to dance/movement schools and ideas developed at the beginning of 20th century.

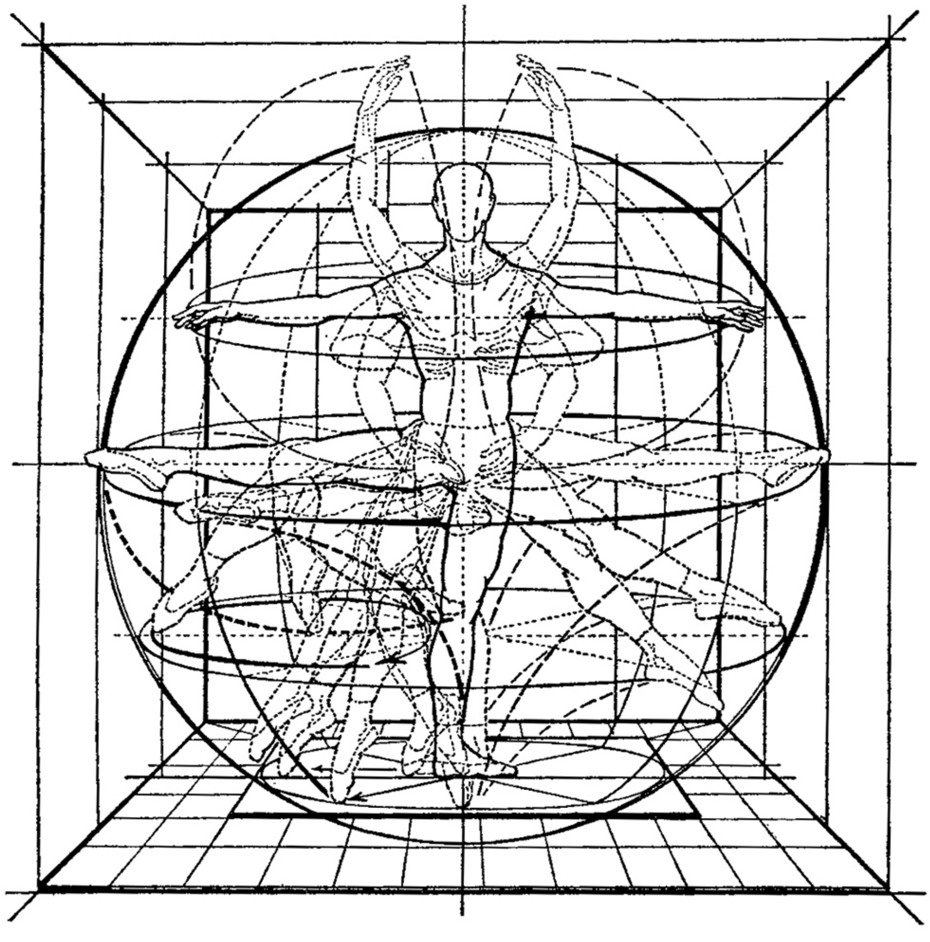

Figure 3.21 Space Modules of the Arms and Legs I, Kirstein *et al.* 1953, p. 2.

The basic premise of Labanotation is the kinesphere, a virtual space that encompasses the body of the dancer as illustrated in figure 3.21.

Laban (1966, p. 10) defines the kinesphere as ‘The sphere around the body that a dancer can easily reach while standing still that moves with the person's traceform in space.’ The ‘traceform’ refers to the path created by dancers’ limbs in space. Kinesphere is related to Laban's theory behind the LMA, named by him Space Harmony or Choreutics, a theory that builds on universal patterns created by nature and man as part of this universal design. I have used Laban's concept of kinesphere in section 4.4.7 *X-Ray of Emotional Kinesphere*. Corporeal movement consists of properties that can be visualized based on patterns referring to geometry, as noted in Gurdjieff's, Laban's, and Schlemmer's dance philosophies and explored by them in movement aesthetics.

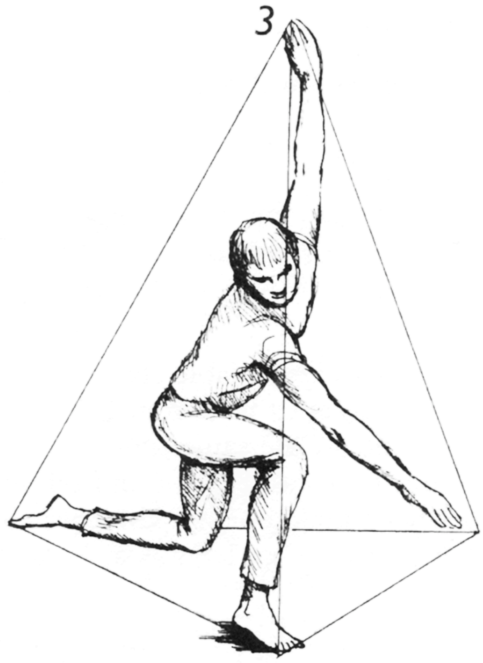

Figure 3.22 Drawing of body inscribed in tetrahedron, John Dalby, 2004, p. 41.

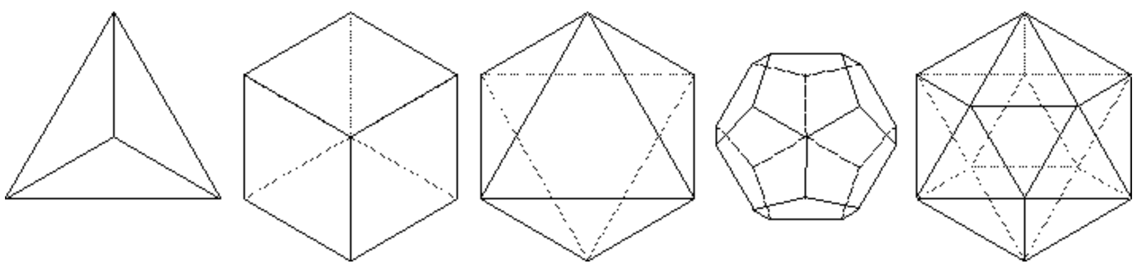

Figure 3.23 Platonic Solids and Sacred Geometry, Rawles, 2013.

Laban perceived human movement as “living architecture” (Laban 1966, p. 5), dividing human movement into weight, space, and time sorted in the form of polyhedrons (Platonic Solids) (figure 3.23), which provide visibility to invisible spatial structures as in the three-dimensional space reflected in geometric structures exemplified in the tetrahedron in figure 3.22.

A movement's appearance/gestalt can be documented by visualizing the connection between volume and movement trajectories in relation to human geometry. This approach is evident in the artwork *Emptied Gestures* (Hansen, 2013), produced by a visual artist and dancer. The two-dimensional images are created by using the artist's own body as a tool to perform movement trajectories on paper.

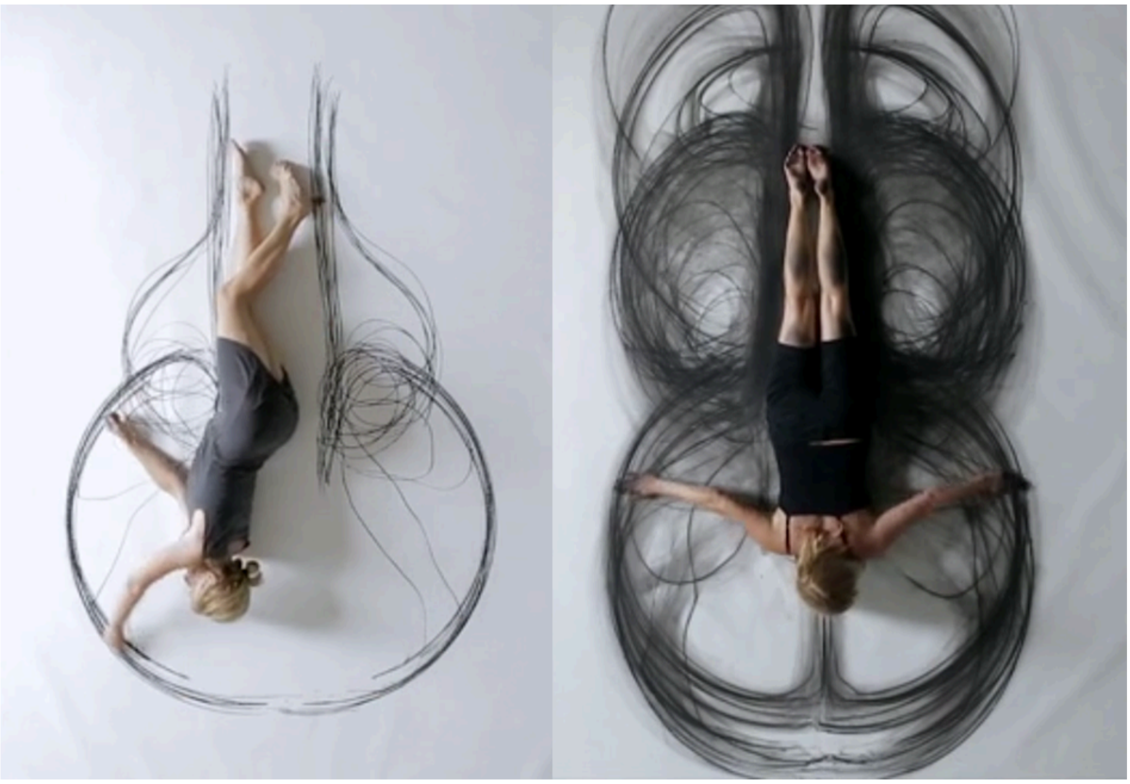

Figure 3.24 Emptied Gestures, Hansen, 2013.

The geometric patterns reflect conjunctions of body geometry with the movement's volume, both manifested by repeated paths in a literary embodiment of kinaesthetic visualisation (figure 3.24).

The visualisation of intensity in a movement's expression seems to be the most difficult part of all movement notations. During the research, the expressions recorded on video provide necessary information about the intensity of movement and the energy required to perform them. However, in the context of a database of movements, browsing large numbers of videos can be extremely time consuming. It is therefore important to find a notation system or simplified visualisation strategy that could be used as a model describing a movement's intensity in relation to space and time.

Laban used Effort to describe energetic dynamics included in the LMA system where movement effort qualities are an inner bodily attitude toward outer movement enactment (Laban, 1950).

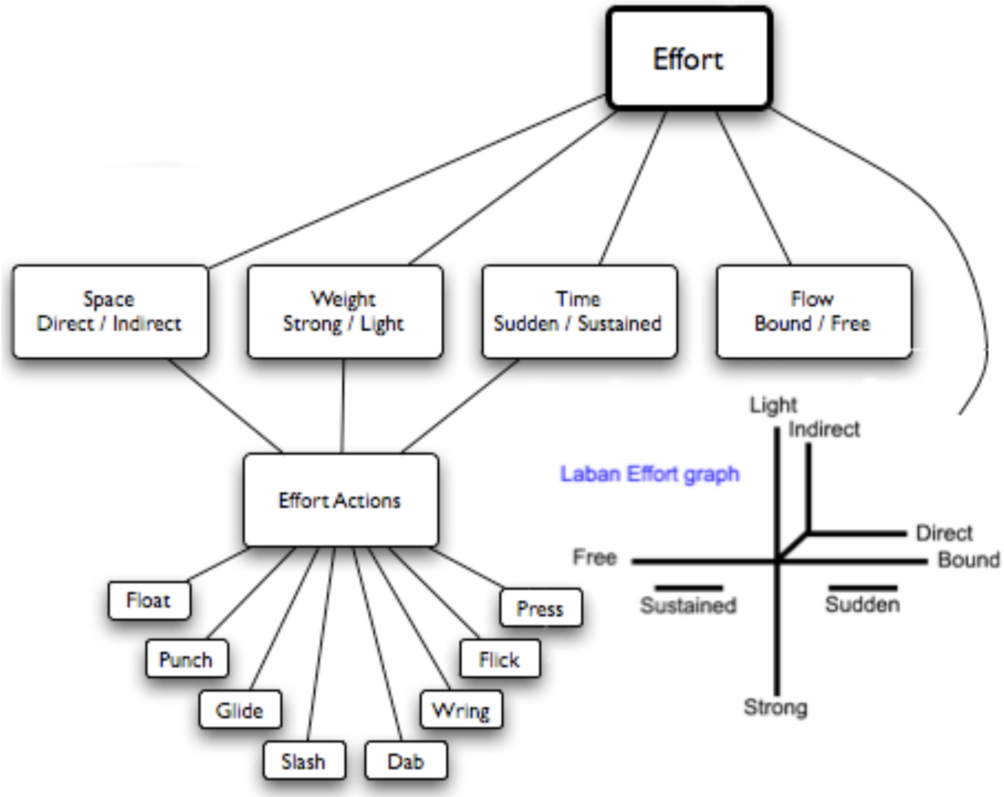

Figure 3.25 Laban Movement Analysis, Ali Momeni (n.d.).

Movement phrasing is characterised by opposites: Mobility/Stability, Inner/Outer, Function/Expression and Exertion/Recuperation. General division of Effort factors, as assigned by Laban, consist of Space, Weight, Time, and Flow. The diagram in figure 3.25 best explains the complexity of Effort.

When looking for descriptive/visual models for energy, and the intention of a movements' expression in relation to time and volume, I originally considered Laban's Effort graph (figure 3.25, lower right), which provided tools for the analysis of movement components, but not for a visualisation. Alternatively, I looked at emotional expressions from a different perspective, via Laban and the work of Mary Wigman (1886-1973) in the context of Expressionist Dance to which I refer in the next section.

3.3.3 Emotions and Movement: Expressionist Dance

Labanotation and Laban Movement Analysis (LMA) are not applied in my working process, but rather function more as an inspiration during the visualisation and workshops in terms of movement, and as personal and architectural elements in relation to space, form, and time. However, the philosophy behind Laban's work provided perspective for contextualising movement and emotions in relation to the expressive dance movement known as Expressionist Dance. In the context of my own research, the idea of movement described below was investigated during the workshops and especially in the context of *Shadow Dance*, a pedagogical tool used during the documentation of expressive gesture, described in section 4.2.1 *Shadow Dance*. In terms of historical perspective, I see parallels between the beginning of the 20th and 21st centuries, since during both periods the conflicts between the human body and technology are amplified.

In the early twentieth century, Europe was dominated by a climate of amusement and public enthusiasm for the technological progress of, and strong belief in, scientific advancement. The arts community first sensed and confronted the problem of human frailty in a world of fast technological advances. At this point in history, Nietzsche (1882) had proclaimed the death of God and in the framework of this idea; the avant-garde movement initiated a new way of exploring art based on the liberation of instincts. It emphasised being in the present by breaking with conventional, traditional ways of thinking and rejecting popular aesthetics of naturalism and impressionism that created impressions of physical reality. Expressionism, in contrast, stressed the emotional experience and the feeling of being alive in the world, with the intention of making an impression on it.

Expressionism is mainly associated with the arts, represented by artists such as Wassily Kandinsky (1866–1944), Paul Klee (1879–1940), and Franz Marc (1880–1916), members of an art group formed in 1911. Following the expressionist movement in the visual arts, Rudolph von Laban (1879-1958), Mary Wigman (1886–1973), Kurt Jooss (1901–1978), Harald Kreutzberg (1902–1968), and his followers established a new dance school—Ausdruckstanz, known as German Expressionist Dance. Von Laban and Wigman played an essential role in the creation of this new movement (Climenhaga, 2013), in which both ballet shoes and clothes were forbidden and dancers were encouraged to show and explore via movement the appearances of human nature from the depths of their soul. The expressionist dance movement introduced a more dynamic interaction between the dancer, the space and dynamic qualities of movement, and allowed dancers to express their personal body language. In this scenario, Laban (via Davies, 2006) relates the notion of presence to dynamic natural movements and provides a method that supported dancers with rhythmic discharge of tension. Laban highlights the need for an individual approach to bodily expressions as well as of the possible effects when the person is not present in the body during the movement (i.e. movement execution is mechanical).

Laban's philosophy states that beyond every denoted symbol of movement exists a dancer, who should interpret these movements with presence in the body based on his/her specific movement characteristics. This approach also applies to physical movement in games in terms of game logic and interfaces, especially since reading and performing dance notations is a cognitive process similar to movement-based games, when movement is an interpretation of visual and symbol-based instructions. My concern is that in the process of game design, movement is considered a minor element and detached from the rest of the body, leaving little or no space for users' individual movement interpretations. Consequently, movements become mechanical or "puppet-like behaviour," as explained by Laban:
Everyone has their individual way of moving.

i. Everyone has their individual way of moving.
ii. Because circumstances often prevent people from following their individual way, it is essential that they are aware what their individual way is.
iii. That awareness can be used to avoid foreign movement (forced on you by circumstances) overwhelming individual movement.
iv. Losing touch with an awareness of one's individual movement shows as puppet-like behaviour. Parts of the body appear to move as though pulled by string and are not integrated into the whole body behaviour.
v. Such forced or puppet-like behaviour is counter-productive in the long term and is associated with some form of stress. Advice should never be concentrated on one part of the body alone, but should be given in the context of body movement as a whole (Laban via Davies, 2006, p. 40).

Laban's principles are applicable to all forms of movement and, in the context of this research, I refer to the body as a prolonged aspect of computational actions, when mechanisation of movements can produce dissonance in the body, for example, stress. In section 3.3.5 *Body, Movement and Technology*, this issue is discussed in the background and based on the research of Ibister (2011a and 2011b) on physical movement in game environments. I use Laban's (via Davies, 2006) statement to support my argument that human movement is not only a locomotion engine, but that expression affects our social communication (Ibister, 2011), psychological well-being, and ability to empathise.

Figure 3.26 Scene from Mary Wigman's “Chorische Studien”, Rudolph, 1929.

The issue of well-being and tension-relaxation through movement and dance is explored in Mary Wigman's (1886–1973) work. Wigman established her own dance school in 1920 in Dresden, known as "Mary Wigman-Schule" that became the centre for expressionist dance, (figure 3.26). Her career as a choreographer began in 1914 and lasted until the 1960s. Wigman is considered the pioneer of German Expressionist Dance, as well as one of the most important figures of modern dance and dance therapy. Her ideas and practices came from studies with Émile Jaques-Dalcroze (1865–1950), Rudolf von Laban (1879– 958), and research on gesture and movement based on the work of Francois Delsarte (1811–1871), a French teacher of the nineteenth century who developed an acting style based on gestures. The most recognisable characteristics of Wigman's dance are expressionism, space, silent dance without music, and the principle of tension-relaxation based on respiratory rhythm. She achieved significant results in the art of improvisation based on movements enacted at low and medium physical levels: kneeling, crouching, crawling, sliding, falling, and sometimes lying on the floor. Wigman had a high sense of contemplative movement inspired by oriental dance's sitting style, using the torso, arms, and hands. Her techniques are considered essential in modern dance, due to her exploratory use of space to recreate movement to visible forms by using the force of the body to direct her energy toward the centre or the periphery of the body. In the context of this research, expressive movements as tension-relaxation techniques are used in relation to the DAMA workshops and the Shadow Dance tool described in section 4.2.1 *Shadow Dance.*

3.3.4 Silhouettes and Expressive Movement

When considering silhouettes as parallel identities seperate from their source, we can focus on bodily expressions. The silhouette on the one hand, forces our brains' processes of interpretation, while on the other it is a simplified reality. In the context of this research on the conversion of video material to silhouettes, this process is technically a preparation for the computational processes based on the features provided by optical movement recognition, a feature used by *Kinect* (Microsoft, 2010) that can distinguish the visual data as shape. Another reason why silhouettes are used is based on my concern that facial expressions would interfere with the image of whole body expressions, both during the online evaluation of the video material and during the triangulation process and posture analyses. Looking at silhouettes in the context of game production, the majority of concept designs begin with the shape model in the pre-production process. This is a method inherited from early animation techniques that collectively with Keali'inohomoku's (1989) Silhougraphs® added a final convenient point for usage of silhouettes as a visual representation of movement in motion.

Figure 3.27 Silhougraphs®, Keali'inohomoku, 1989.

The idea of silhouettes as models for expressive movement recordings is not new, yet I determined that it is the most suitable for the database. Silhouettes as a visualisation method have been used both as a research tool and in the documentation of performative techniques in Silhougraphs®.

Silhougraphs® is an anthropological study of dance by Keali'inohomoku (1989, 2008) applied as a complementary feature for dance notations such as Labanotation and Benesh Movement Notation (Hutchinson, 1954, Benesh and Benesh, 1956). It is worth mentioning that Keali'inohomoku used silhouettes for the purpose of emphasising the diversity of the characters of dancers and their costumes that movement notation was unable to provide. In considering games and concept design, silhouettes are often used both to highlight the differences among characters and to simplify the production process.

Figure 3.28 Videoplace, Krueger, 1970-1990.

In 1970 Myron Krueger, an early pioneer of virtual reality and interactive art investigated how the silhouettes of spectators could become the visual interface for a full-body and participatory, series of interactive artworks. In *Metaplay* (Krueger, 1970), via video cameras and real-time computer interaction, a live image of the viewer and computer graphic drawn by an artist working remotely, were combined on a projection screen. The project was one of the first experiments based on the concept of shared telecommunication spaces.

The experiment initiated the development of the artificial reality laboratory that became known as *Videoplace* (Krueger, 1985), a pioneering work that introduced interactive computer art and responsive environments and the concept of virtual reality (figure 3.28). During the period from 1970 to 1990 the *Videoplace* environment expanded producing 20 different installations that could respond to the visitor's movements and actions.

In several iterations of *Videoplace* Krueger explored the relationship between human, machine and space as an aesthetic dimension (Hinrichsen, 1999), in which the computer creates graphics as visual responses to the bodily actions of spectators. Krueger (1991) formulated the idea in terms of human actions and machine reaction, i.e. the relationship between input and output:

> An artificial reality perceives a participant's action in terms of the body's relationship to a graphic world and generates responses that maintain the illusion that his actions are taking place within that world (Krueger, 1991, p. 59).

Krueger also describes *Videoplace* (Krueger, 1991) as an environment in which communication between the human and virtual space is explored as an aesthetic dimension created by the visual and bodily experience.

> In general, I have stuck to the premise that everything that happens should be a direct response to the participant's actions. However, within that discipline a number of different kinds of pieces can be developed (Krueger, 1991, unpaged).

Krueger (1991) highlights the premise of interaction as an artform, signposting the way for future developments. The issue of expression as a starting point for interaction is a central concept of *Videoplace* (Krueger, 1985). Expanding nuances of embodied responses, the computer mediates and re-mediates participants' physical actions converting them to new visual graphic forms.
The shadows of the participants reproduced in the computer's visual display formed a novel relationship between a human and a machine (computer). In this situation the digital dimension has enabled new forms of expression that has forced participants to understand themselves within a new context of physical activity evoked by a machine.

Analogously, the concept of co-presence and embodiment is challenged by the media artist; Lozano-Hemmer in the installation; *People on people* (Lozano-Hemmer, 2010) co-commissioned by Manchester Art Gallery and Abandon Normal Devices (AND) for the Festival of New Cinema and Digital Culture in 2010. The artwork synchronises projected silhouettes of gallery visitors with a series of captured images of other visitors incorporated inside their projected shadows (figure 3.29).

The artist employs technologies such as high-resolution surveillance cameras with face recognition and 3D tracking for capturing and rendering gestural data. This setup provides visitors with tools for augmented body experiences through postures and gestures, which is of high interest in the context of this research. During the installation, through the juxtaposition of corporeal movement and facial expressions Lozano-Hemmer (2010) manage to create a unique collage of recorded presence and a playful sensation of discovery.

Figure 3.29 People on people, Lozano-Hemmer, 2010.

Another of his earlier interactive installations; *Body Movies*, *Relational Architecture 6* (Lozano-Hemmer, 2001), a touring exhibition to cities around Europe and America transformed public spaces with the interplay of previously captured portraits and the silhouettes of by-passers as well as providing visitors with a performing space (figure 3.30). The installation is based on a database of 1200 portraits and custom written software that analyses video frames to detect the contours of silhouettes. In this case, *Computer Vision* was used to determine the location of these silhouettes allowing projected portraits to appear only within the silhouettes' boundaries (Cantz. 2002).

Figure 3.30 Body movies, Relational Architecture 6, Lozano-Hemmer, 2001.

Embodied actions that create alternative responses thereby stimulating new physical actions is an approach discussed in section 3.4.2 *Bridging Boundaries: body>data>body*. These examples of Lozano-Hemmer's (2001, 2010) work typify embodied art extended into public spaces, where interactive, real-time visual data encourages participants to interact and collaborate with others. In this case, visitors create an outcome that has not been pre-programmed by the artist. In terms of the technology employed, I was interested in designs that use *Computer Vision* and especially the possibilities of matching projected movement with the visual data contained in the PTM database, a design that is often evident in Lozano-Hemmer's artworks. What I intend to highlight in his artworks are the use of public space and the power of spontaneous actions that reflect human non-verbal communication skills.

In an attempt to find emotional expressions that resonate powerfully through the use of shadows, my explorations led me to silhouettes in motion exemplified in *Shadows* (Fernandez and Weiss, 2003). It is the cooperative work of the dancer Emily Fernandez with video technologies and interactive stage projections developed by Frieder Weiss. Similarly, *Shadow Mechanics (*Craig, 2007), is an exploration of Meyerhold's biomechanics system. Andrew Harwood's and Benno Voorham's dance performance *Transatlantic Misunderstandings - excerpt Improvisation* (Harwood and Voorham, 2009) explores dialogue between dancers' shapes. These artists' approaches represent an insight into silhouettes as choreographic and narrative values in interactive dance pieces.

Figure 3.31 Shadows, Fernandez and Weiss, 2003.

Shadows (Fernandez and Weiss, 2003) illustrated in figure 3.31 offers a convergence of technology, dance, and choreography in an interactive dialogue between the dancer and their alter ego, a projected shadow. The poetics of the choreographed movements are based on the shadow that grows out of the dancer's body in juxtaposed or repeated movements with a delay, which multiplies itself in the visual cascade of gestures represented in contrasting black and white silhouettes. The interactive computer system designed by Weiss, allows the dancer to control sound and projections in real-time. Weiss, an expert in real-time computing and interactive computer systems, has a long record of collaboration in performance art. He has contributed to several significant works in dance, music, and computer art based on the video motion sensing programs EyeCon and Kalypso (Weiss, 2008), developed by him as an extension of video technologies used with interactive stage projections.

Figure 3.32 Two frames from Shadow Mechanics, Craig, 2008 (upper); graphics, Lyutse, 1922 (lower) via Braun, 2013, p. 173.

Shadow Mechanics (Craig, 2007) is a good example of a film displaying the potential of silhouettes as a graphical and visual medium for movement, highlighting the textual quality of the body integrated into the scenery of the stage in line with Meyerhold's intentions (Craig, 2007). Figure 3.32 (upper image) shows a frame from the film, (lower image) illustrates graphics from a drawing series; *Biomechanics exercises*, (Lyutse, 1922 via Braun, 2013) inspired by the prevailing art style.

Craig emphasises Meyerhold's emphasis on biomechanics in which the actor focuses on the general character of the body without the influences of individual emotions. ‘The whole biomechanics system, the entire process of our movement is directed on one basic principle—our capacity of thought, the human brain, the rational apparatus' (Meyerhold via Braun, 2013, p. 176). However, as Craig (2008, unpaged) also points out, 'Connected to this fact is that the human body is a highly individual and specific entity, with specific and unique characteristics. It also expresses an individual personality.'

According to Whyman (2008), Meyerhold's system was intended to augment the sculptural qualities of body emphasising visual qualities of physical movement towards the machine as a part of a bigger construction than human personality by itself.

Figure 3.33 Transatlantic Misunderstandings, Harwood and Voorham, 2009.

Transatlantic Misunderstandings - excerpt Improvisation performance (Harwood and Voorham, 2009) drew my attention when I was searching for examples of the aesthetic value of silhouettes in contemporary performance (figure 3.33). During part of the performance the silhouettes are used as amplifiers of the emotional tension between the two men, which is performed with grace and sensitivity by the two dancers. The frailty of the silhouette movements on the wall works as an extension of the two dancers expressing their emotions and augments a visual dimension to the dancers themselves. These types of narrative dialogues and interrelationships between silhouettes, was explored further in the PTM database material when considering other possibilities for future use.

This is a parallel conceptual sidetrack reflecting my philosophical detours, about the position of emotive expressions in the hierarchical structure of knowledge. In the framework of visualisation methods used during the research to index the analogies and distinctions among shapes/postures, a colour-labelling system was implemented for each of the four emotions based on Plutchik's colour wheel. As a result a circular correlation diagram was created as the final visualisation of the Periodic Table of Movements.

In terms of the human body as the object of investigation and from the historical perspective of an assessment of the arts, I refer to the Bauhaus art and craft school in Dessau and the Bauhaus Stage project (1921-1929). The Bauhaus Stage project is especially significant as it contributed to innovatory experiments in terms of visualisations of the human body and space in the context of the technical developments occurring during the 1920's. The project was created 'with the aim of investigating the "mechanical and organic body" in the context of space, movement, form, colour, light and sound' (Bauhaus Dessau, 2013, unpaged). For the opening of the exhibition; *Human-Space-Machine. Stage Experiments at the Bauhaus* (Bauhaus Dessau, 2013), a number of questions that lay behind the emergence of the Bauhaus Stage project were articulated:

> Which utopian ideals motivated this work on the "new human being"? What kind of modern man did the Bauhaus envisage would inhabit this world defined by technology? And what did he expect of it? What happens to the heart and soul, the mind and body, the individuality of a human when he and his environment are defined, rationalised and standardised by technological, mathematical and scientific parameters? Might his sensibilities and creativity, his productiveness and life energy, be enhanced by technological appliances? (Bauhaus Dessau, 2013, unpaged)

The main protagonists of the 'new, modern subjectivity' (Bauhaus Dessau, 2013, unpaged) were: Walter Gropius (1923–1969), Oskar Schlemmer (1888–1943) and László Moholy-Nagy (1895–1946).
In the context of silhouettes I refer to Moholy-Nagy and one of his inventions, *Light-Space Modulator* (Moholy-Nagy, 1922-1930), a device where light is projected onto metal mobile discs casting reflections and shadow formations onto its surroundings (figure 3.34). This kinetic sculpture, based on light, movement, and the silhouettes of objects is one of the early examples of lumino kinetic art.

Figure 3.34 The Light Space Modulator, Moholy-Nagy, 1930.

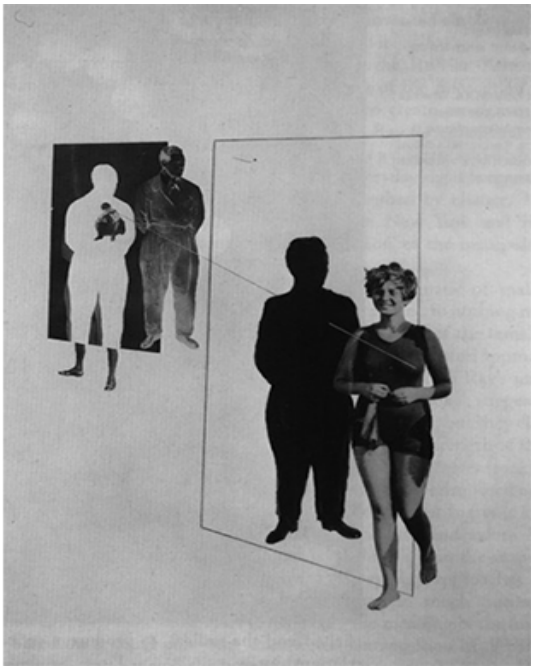

Figure 3.35 Photogram 1 & 2, László Moholy-Nagy, 1928.

The idea of shadow-light as negative and positive space was also explored by Moholy-Nagy (1922-1943) in his early experiments where light-sensitive paper was exposed with objects overlaid on top of each other during the photographic process, producing both photograms and photomontages (figure 3.35).

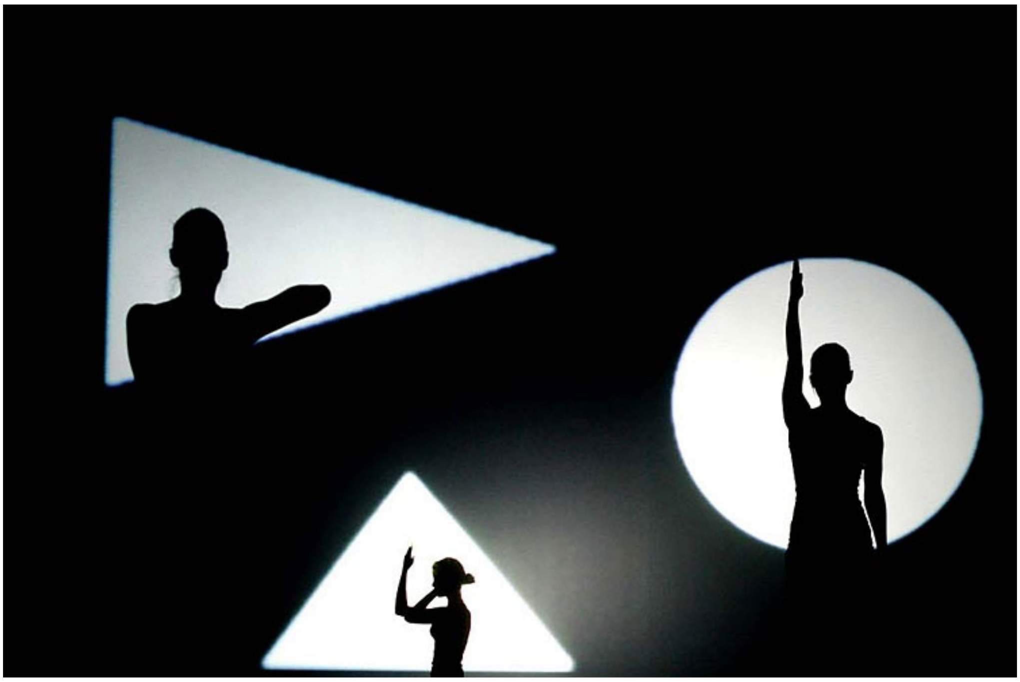

Figure 3.36 Dance performance, Negative Variate, 2011.

Based on Moholy-Nagy's film manuscript; *Dynamic of the Metropolis* (1921/1922) his concept of shadow and light was explored by ballet dancers during the performance *Negative Variete* (Negative Varieté Company, 2010) created as a tribute to his art and performed in Budapest on several occasions between 2010 and 2013 (figure 3.36). The first performance was followed by an interactive *Negative Variete Photo Installation* (Bujnovszky, *et al*., 2010); a documentation of the dance performance based on Moholy-Nagy's technique of photograms.

Figure 3.37 Two screenshots from The Adventures of Prince Achmed, Reiniger, 1926.

Analogously, pioneering a unique style of black and white silhouettes, Lotte Reiniger (1926) a German animated film director, used photograms during the production of a feature-length animated film; *The Adventures of Prince Achmed* (Reiniger, 1926, 1970) (figure 3.37). Inspired by traditional Chinese shadow theatre, she developed an advanced paper cut-out technique (Reiniger, 1975). During her life (1899–1981), she produced over fifty short films (Milestone Films, 2001) revealing the complexities of silhouettes in a new and sophisticated manner, exposing the emotional expressions of the intricate shapes and the subtle movements of the paper actors. Reiniger's animations demonstrate through pure visual storytelling the power of gestural expressions augmented by silhouettes.

I often return to the artforms of the first part of the last century, since I found that different art practices widely explored the confrontation of body and technology during this period. I draw parallels between investigations into the mechanical versus the organic in the context of industrialisation and investigations of the digital versus the corporeal against the background of the contemporary development of digital technology.

The connection between past and future is important in terms of an expressive movement database and games development and specifically in the context of character design. Movement and gesture are used in conjunction with concept design where silhouettes are employed as a part of the production process in both games and animation. Initial thumbnail sketches have an important function in the design process where the use of shape is an attempt to distil the essence of the character in order to distinguish its most characteristic features, as well being a time-saving technique that produces concept variation (Corriero, 2011).

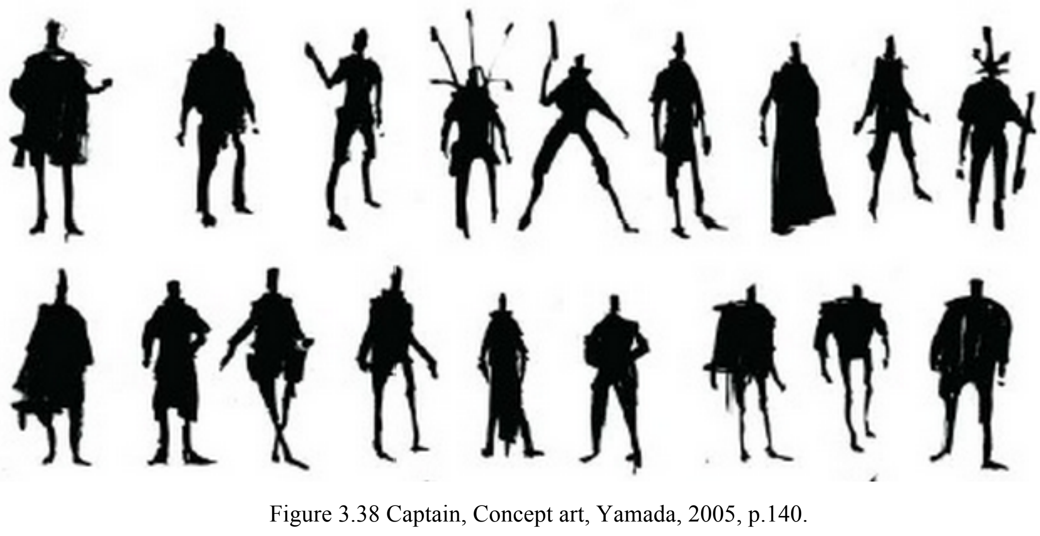

Figure 3.38 Captain, Concept art, Yamada, 2005, p.140.

Figure 3.38 illustrates the first steps of character design for games by concept artist

Yamada (2005) where a multitude of shapes provides the ground for the final character. During the design process, the details of the final character crystallise from several shapes, as shown in Yamada's concept art, figure 3.39.

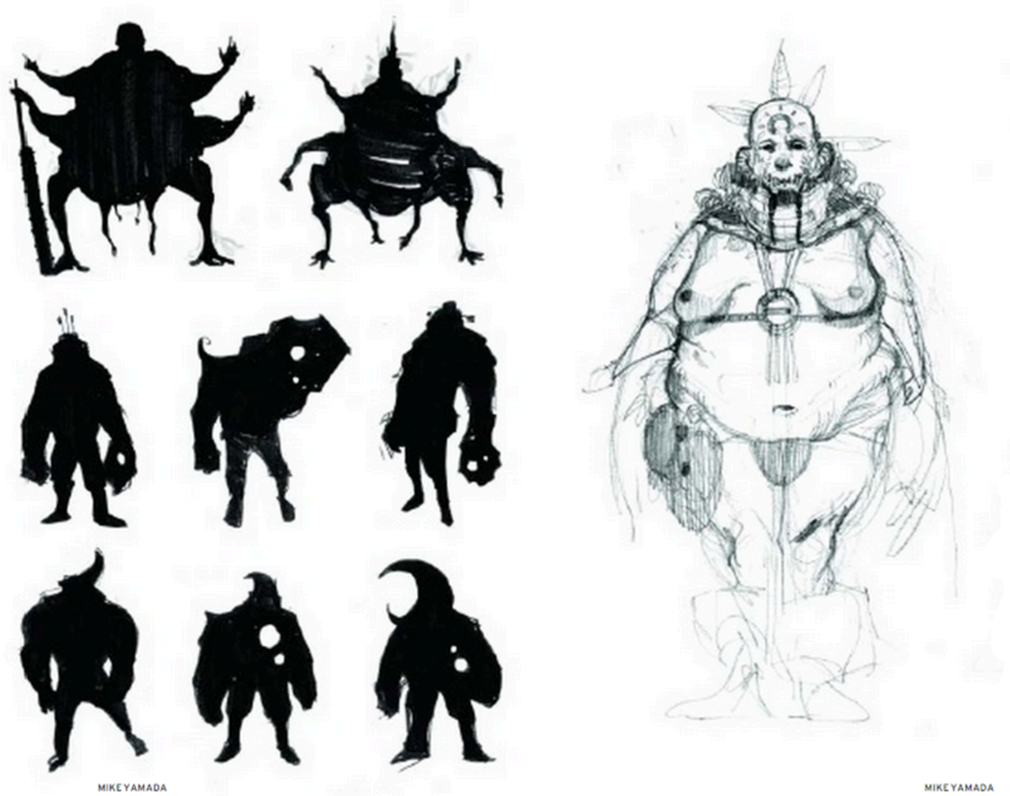

Figure 3.39 Giants, Concept art, Yamada, 2005, p.79.

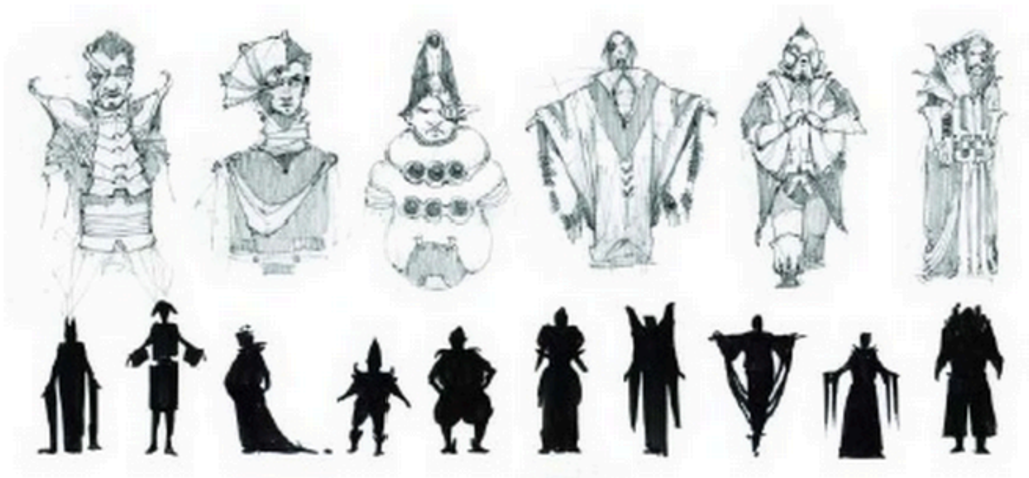

Figure 3.40 Concept art, Khang Le, 2005.

In order to develop a unique idea, the artist relies on the silhouette of the character to provide the narrative value to a story, therefore, focusing on the character's posture needs to be highlighted before the design of any details.

This applies both to the design of a single character and a group of characters as illustrated in the concept art of Le (2005), in which shape highlights the story-based personality, (figure 3.40).

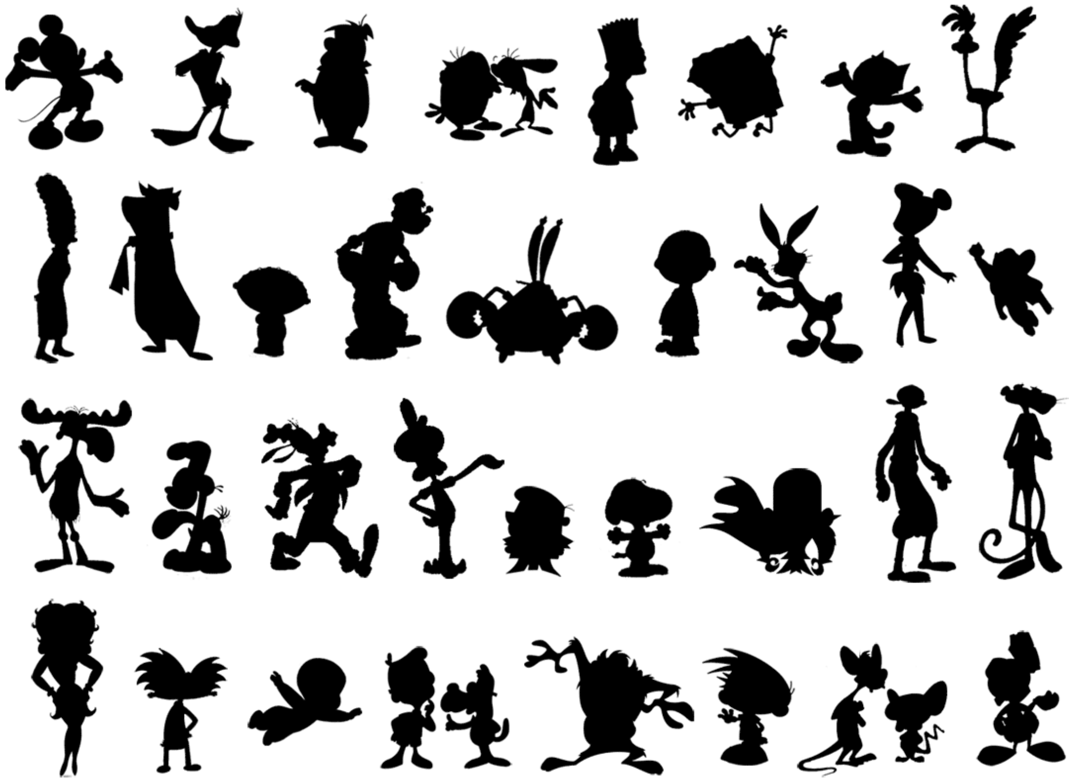

Figure 3.41 Classic silhouettes, Flynn, 2008.

The silhouette technique has a long history in animation, practiced by nearly all animation studios as part of the production process. Good character design embodies the easy identification of the character from their silhouette via the silhouette test.

Flynn (2008) as an illustrator, artist, and animator emphasises this point, stating that most people can recognize a cartoon character just by looking at its shadow and uses classic cartoon silhouettes, (figure 3.41) to support his argument. Stanchfield (1980), animator and mentor of Disney animators, pointed to the value of the silhouette test,

> A long-standing rule in animation is that a good extreme pose should read in silhouette. This means that you should be able to "black in" your pose and still see clearly what the character is doing (Stanchfield, 1980 via Hahn, 2013, p. 15)

In this case, the main function of the silhouettes is that characters should be quickly identifiable in the outline highlighting action lines. This way, the silhouettes render the possibility to evaluate the body language of the character. For this purpose, Disney animators used a room specially designed for movement exercises, where they were able to act out and see the silhouette of the body for their key poses (Valdez, 2010b).

By using silhouettes as a central resource for the PTM database, I intend to highlight the characteristics of emotional expressions, which via existing character design methods could be used in animation for games. Based on my experience as a teacher, this approach could provide a tool for action analysis, especially for students that have no idea where the pose sequence starts and ends and have problems when modifying poses to enhance weight and timing. Furthermore, enhanced by Kinect's technology (Microsoft, 2010) the database could be used for the future development of natural, movement-based interfaces as feedback for players, all feasible with Kinect's shape and gesture recognition capabilities.

The difference between traditional 2D and 3D animation for games is that the movement overstatement is rooted in the long-lasting culture of 2D animation whereby 3D animation usually imitates emotional expressions in a more naturalistic manner. Computer Graphics students often focus on the technical aspects of 3D animation. As a result, this has the disadvantage of producing 3D characters in games that often move in an uncanny way. Therefore, tools for explorations of emotive expressions could provide human body and motion awareness. Stanchfield (2006, p. 1) highly recommends that his students: ‘Draw ideas, not things; action, not poses; gestures not anatomical structures’. To which I need to add: feel emotion through your body.

In order to avoid unrealistic characters, the solution is to animate 3D characters with more expressive gestures, or to let gamers themselves via natural movement recognition technology provide more “soul” to the characters. I refer here to a famous quote of Leonardo da Vinci: ‘Build a figure in such a way that its pose tells what is in the soul of it. A gesture is a movement, not of a body but of a soul.’ (Da Vinci via Stanchfield, p. 5).

3.3.5 Body, Movement and Technology

> *The necessary foresight for the solution of our age must come not only from the deepest scientific thought but also from the deepest of artistic thought. (Shore, 1986, p. 5)*

The expansion of social networks, digital communication tools and entertainment such as games, have become part of our daily lives, yet, with the expansion of the digital culture the behavioural characteristics of human bodies have still not been fully taken into consideration. This section focuses on examples that explore non-verbal communication as well as the visual and physical experience of the human body in connection to computer based technology. Both the art scene and social science explore boundaries of the human body where interface design, portable gesture recognition technology and visualisation play essential parts in the process to reinforce bodily activities, and embodied behaviours in structures that builds on the logical algorithms of computer programs.
In this part of the subject study, contemporary art/performance art and research are discussed from the perspective of digital technology in relation to the human body and motion.

According to Freedberg and Gallese (2007, p. 197) throughout the history of art, the image of the human body '...simulated the senses of actions, emotions and corporeal sensations as a universal mechanism in the human perception of embodied art', as a bridge to conscious and subconscious empathetic responses. In the course of this research, many questions have been asked with regard to the field of neuroesthetics. The term neuroesthetics emerges primarily from the cognitive neuroscience and arts sector as a field of cognitive neuroscience which explores the '...universal perceptual rules in an attempt to explain what art is, and what aesthetic pleasures we derive from it, on the basis of psychophysical and neurocognitive knowledge of the visual part of the brain.' (Freedberg & Gallese, 2007, p. 197).

With this in mind, and in terms of applicable movement sensing technologies I have focused on human-computer communication as a bi-directional process, i.e. expressive movement as input data visualised as transformations on screen, and feedback actions that inspire participants to undertake new movements. The issue of feedback produced by computational systems has an impact on all design of virtual applications.

Historically, it has been shown that humans are one group of creatures that easily adjust to new circumstances as supported by evidence in neuroscience:

> We know that all brains in the animal kingdom adapt to their environments, … but human brains do it superlatively. It follows that if you put the brain in an unprecedented environment it will follow its evolutionary mandate and adapt (Greenfield via Carr, 2010).

Considering that humans adapt easily to new circumstances, it is essential that we do not simply adjust the physical body to work with computer interfaces without reflection. Many interfaces are constructed on premises dictated by simplifications rooted in the computational processes where natural human physical movement was not prioritised. This circumstance creates physical movement mechanisation, a form of adaptation that often leads to movement simplifications and unconscious robot-like behaviour (Isbister, 2011; Laban via Davies, 2006; Turkle, 1984), movements that are detached from the factual framework of the human body.

Perception of the human body in the digital age and with the new strategies discussed by Broadhurst (2007), addresses the interface between the physical and the 'virtual' as a part of the theoretical approach that builds on the aesthetics of performance within new technologies. Additionally, Munster (2006, p. 26) debates a corporeal virtual experience and uses the term "reconfigured bodily experience" in describing a new level of experience as a new logic in the non-liner sense. Adding that, the 'digital embodiment' is a process in which '...individual bodies engage with digital codes to produce new and different sensations and affects…' (Munster, 2006, p. 26) in the process of "reclaiming" the digital space and technology.

The terms expressive movement and movement recognition technology need further explanation, specifically since these terms are partly my own invention. The term expressive gesture is described by Camurri (2004) in *Multimodal Analysis of Expressive Gesture in Music and Dance Performances* where the term expressive is grounded in Laban´s *Movement Analysis* and Laban's term; expressive content (Camurri *et al.*, 1999):

> In artistic contexts and in particular in the field of performing arts, gesture is often not intended to denote things or to support speech as in the traditional framework of natural gesture, but the information it contains and conveys is related to the affective/emotional domain. From this point of view, gesture can be considered "expressive" depending on the kind of information it conveys:

> expressive gesture carries what Cowie et al. (2001) call "implicit message", and what Hashimoto (1997) calls KENSEI. That is, expressive gesture is the responsible of the communication of information that we call "expressive content". Expressive content is different and in most cases independent from, even if often superimposed to, possible denotative meaning. Expressive content concerns aspects related to feelings, moods, affect, intensity of emotional experience (Camurri *et al.,* 2004, p. 21).

However, I argue that the term gesture is not sufficiently descriptive in terms of acting, since it does not reflect the entire spectrum of possible body movements. I found this problematic, especially when working with dancers and performers, since ‘gesture’ for us is related to the upper part of the body. The term *expressive movement* includes both gesture and whole-body movement. Therefore, *expressive movement* becomes a transition or merging, hand-in-hand with technical and performative content, allowing dancers and performers to focus on the expression and on the particular part of their body. As a consequence of these cultural and semantic detours, the commonly- known term ‘gesture recognition technology’ becomes ‘movement recognition technology’, explained as follows in the context of its technical aspects.

3.3.6 Technology; Perceptual Interfaces and Movement Recognition

The development of perceptual interfaces, allows users to communicate movements and gestures without the need to wear, hold or make physical contact with any device. These features have provided new solutions, based on input from face, whole-body, and gesture movements. Shneiderman (2002, p. 2) describes the paradigm shift: ‘The old computing was about what computers could do; the new computing is about what users could do. Successful technologies are those that are in harmony with the users’ experiences’. This is an ideal situation, which I believe will develop new participatory experiences “on” and “off” the performance stage, as well as in the games that were often the object of my concern, particularly regarding the body's position, literally and metaphorically. Movement recognition technology allows users to sense the body's movements based on perceptual input devices that can track and register these movements, and communicate the data to a computer in order to control devices or applications. The input could be optical, such as a simple RGB web camera, or something more advanced, based on ‘depth sensing’, such as an infra-red projector and corresponding infra-red camera. In this case, an invisible pattern of dots is projected and is captured and measured by the infra-red camera.

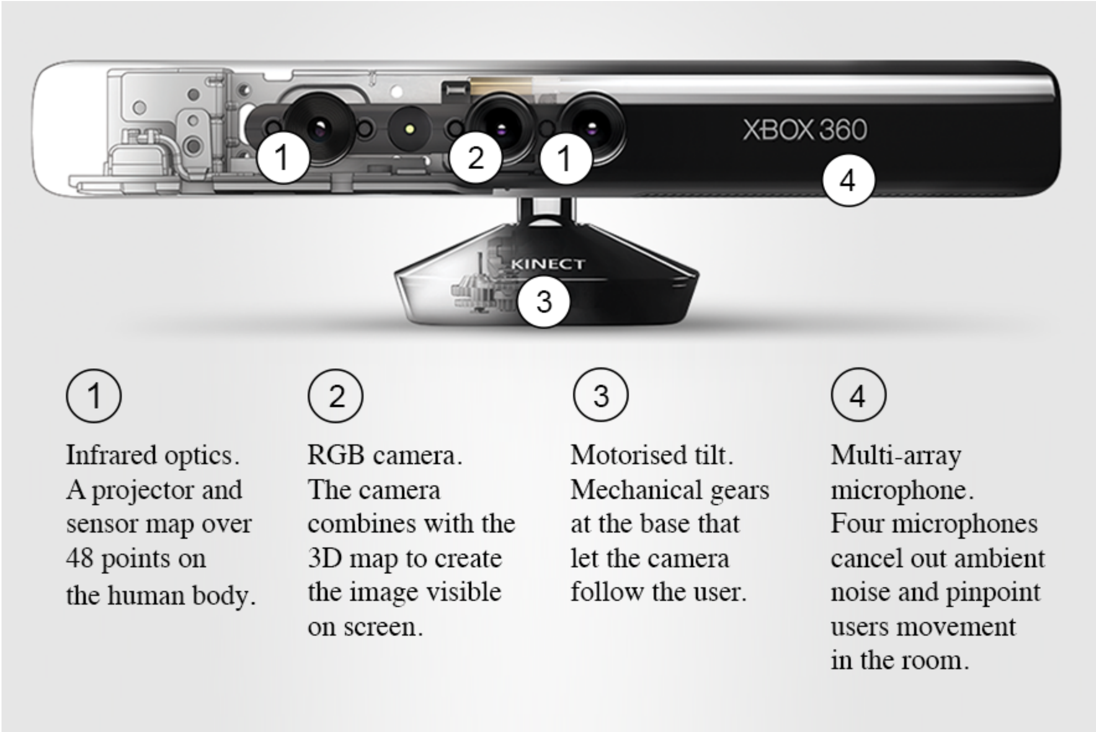

Figure 3.42 Kinect for Xbox 360, Microsoft, 2011.

Algorithms use this depth information to process the subject's posture, as well as the position and orientation of their limbs. This technique is used in Microsoft's (2010) Kinect for Xbox 360 (figure 3.42) and in other motion capture technology. The difference between this technology and motion capture (MoCap) is that MoCap is based on reflective on-body markers that provide positional information for multiple cameras in order to capture movement data from different angles. Wii Remote (Nintendo, 2006) is a wireless controller, suitable only for gestures. It is based on a Broadcom Bluetooth chip that is wireless, sending a constant stream of position, acceleration, and button-state data to the Wii console. These technologies provide new possibilities to interact with computers through whole-body movement and gestures, and the recent development of portable gesture recognition such as Kinect (Microsoft, 2010), PlayStation Move (Sony, 2010) or Wii Remote (Nitendo, 2006) – all primarily developed for the game console users, are becoming available at low cost.

The game industry is leading the research and development of motion response technology. For example, Sony's hands-free, whole body tracking image-sensing system was created in collaboration with Atracsys (2013), a Swiss optical tracking company. Another is Microsoft's Kinect developed under the project name Natal and released in November 2010 for the Xbox 360 video game platforms.

Figure 3.43 Kinect Skeleton Tracker, Depth Stream (left), Skeleton (right), Screenshot, Hrynczenko, 2013.

Kinect (Microsoft, 2010) has many advanced features, including voice recognition and a video camera for face recognition, as well as being able to detect RGB colour components. The most innovative development is “depth mapping” which can detect 48 points of a moving body. Depth sensing is based on an infrared projector that can recognise 3D bodies or objects in a room regardless of the lighting conditions. Point detection (figure 3.43) is an advanced feature that allows a digital reproduction of the user's body shape and skeletal structure (Microsoft, 2011). This set of features enables human body movements to be used as input devices; a Natural User Interface (NUI). According to the Guinness Book of World Records (Van Camp, 2011), Kinect was the "fastest selling consumer electronics device" with 8 million units sold during the first 60 days.

Based on Kinect's (Microsoft, 2010) popularity together with the research from Latitude (2011) described in section 3.3.9 *Physical Body, Emotions and Games*, it is obvious that games based on whole-body movements are in demand. At the same time, Kinect also became a tool for experimentation beyond the video game console, the Xbox 360, providing new applications in movement recognition for portable 3D scanners. In this context, Kinect's history provides an interesting turning point that shows that the release of the open source code of the software development kit has expanded Kinect's implementation areas and shaped new creative applications (figure 3.44).

A short time after Kinect (Microsoft, 2010) was released, the open source community provided a software driver that opened up the USB connection allowing use of both its RGB camera and its depth sensitivity functions.

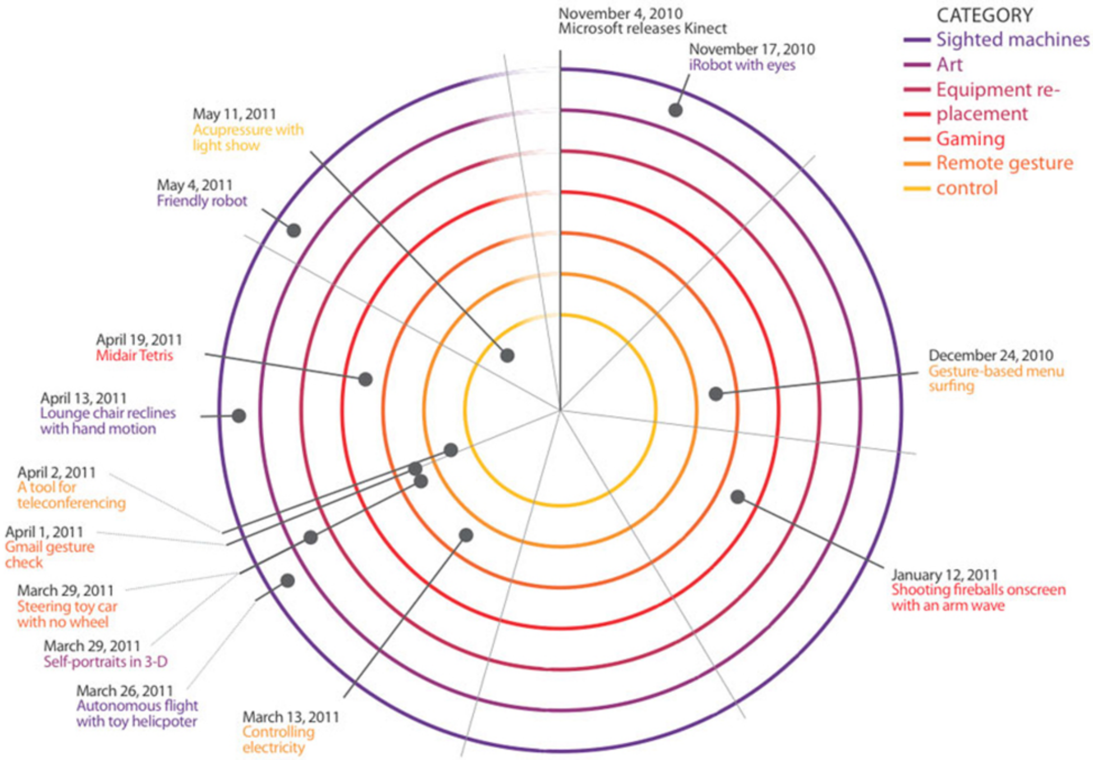

Figure 3.44 Kinect's usage development 2010-2011, Popular Science, 2011.

This development had an effect on the "Hack the Kinect" competition for the "Open Kinect" project announced by Adafruit (Adafruit, 2010) that promised a prize of $3,000 for the first Open source software driver for the device. In response, PrimeSense, whose depth sensing design Kinect is based on, released their own driver, OpenNI, as open source software. Shortly afterwards Microsoft decided, after a change of mind, to release their own version of a software development kit (SDK) for open source use.

This started a wave of creative projects that used Kinect beyond the gaming environment, producing movement-based applications for different fields, such as robotics, medicine and art. The first seven months of these developments are illustrated in figure 3.44 from Popular Science (2011) providing an overview of the Kinect's open source SDK's effects. The diagram illustrates the creative possibilities that evolve when new technology is shared across different fields of knowledge.

Kinect's (Microsoft, 2010) free SDK opens possibilities for the future development of new Kinect based applications and introduced a paradigm shift in the development of body-centred software applications and content. The Kinect sensor together with the SDK provided convenient and inexpensive motion tracking equipment by providing colour, depth, and skeletal information tracking.

The simple interface design and the open SDK of Kinect provided new possibilities for embodiment in computer-related art. The OpenKinect community of artists, home-innovators and people sharing knowledge, developed many of these designs and provided tutorials, examples and open source code. These open source communities have proven that an innovative and experimental approach, outside the context of the Xbox, could provide new applications for the technology in totally different fields than the initial games market that Kinect was designed for (Weldon, 2012).

Kinect's technology (Microsoft, 2010), and innovations that it displays have received wide attention in the fields of medicine, psychology and research across many disciplines and in various forms of artistic expression.
As Shneiderman (2002, p. 2) indicated, 'Successful technologies are those that are in harmony with the user' we can observe that emerging technology is opening doors for a paradigm shift in the way we look at the human body and expressive gesture in the context of digital environments. Underlying this scenario, existing tacit knowledge contained in centuries of performance art culture is of significant importance to the connection of body-centred knowledge with technology.

3.3.7 Movement Recognition Technology and Art

From a historical perspective, it seems that the development of NUI interfaces for public use has taken very long time to evolve. In fact, the body as an interface was introduced in 1922 by the early Russian electronic musical instrument, the theremin (Glinsky, 2000). In 1965 movement based interaction was shown during Nam June Paik's exhibition *Magnet TV* (Paik, 1965), spectators could produce oscillating patterns on a TV screen. David Rokeby, inspired by the theremin in 1984, transformed body movement to sound in the performance/installation, *Body Language* (Rokeby, 1984-86). Later, in 1986, he developed a motion reactive music instrument – his *Very Nervous System* (Rokeby, 1986-1990), where the human body was acting as an instrument, creating acoustic work through its movements. These two art works exemplify situations where human embodied perception was amplified by technology and controlled by corporeal movements. Broadhurst (2007) defined this phenomenon as: 'The technology and instrumentation extending the body by alternating and recreating its embodied experience' (Broadhurst, 2007. p. 24). Furthermore, she described the potential of this process as '...the body in turn creates new technologies and instrumentation to bring potential creativity and mediation into its corporeal word'

(Broadhurst, 2007. p. 24).

In the scope of technological advances, many artists not only use existing software and hardware, but also invent new ones. Several artists use existing technologies to drive their own work and conceptual models in new ways by adapting the technology to their own artistic expressions. In many cases, development is driven by artistic vision in single artist projects or in collaborations, as in the case of the project *G-Vision* (Johnson *et al.,* 2006) by artist and researcher Nigel Johnson. *G-Vision* is a software tool for real-time gesture and motion recognition used for interactive installation and performance scenarios, which has been developed in the frame of an artistic research project in collaboration with the School of Computing at the University of Dundee, Scotland, U.K. In the context of this review, the artistic vision provides an insight into the possibilities that movement and gesture recognition software and hardware can offer, illustrating that at the same time imagination is a starting point for all development:

> Imagine a symphony of sounds raised by the movements of a conductor's hands even though there is no orchestra, or images that change depending on the number of people looking at them and where they are standing. Imagine art and the interaction experience that can be influenced as much by the audience as by the artist (Johnson, 2006).

New possibilities evolve with movement recognition technology accelerating both software and hardware development by companies and artists. These different approaches in the artistic field are investigated by referring to projects and research that merge movement-based art, dance, choreography or performance with new technology. The development and use of movement-based software has a long tradition in the field of Dance and Technology in an ever-expanding network of collaborative projects. Several artists have contributed to new software, tools and platforms for research that grows from artistic vision and the need for experimentation with the new possibilities that computer technology can provide.

Dancer and choreographer Merce Cunningham (1919 –2009), was a pioneer in the field contributing with software *LifeForms* (Cunningham *et al.,* 1989) based on forms of chance operations and the possibilities of motion capture. Troika Ranch and its co-founders Coniglio and Stoppiello, were among the pioneers in the field producing the software, *Isadora* (Coniglio *et al.,* 2002). Susan Broadhurst used software for 3D character that was specially adopted (Bowden, 2002) for her performance project

Jeremiah (Broadhurst, 2001) and Frieder Weiss used interactive software and hardware, *EyeCon* (Weiss, 2008). Collaborators Frieder Weiss and Klaus Obermeyer (n.d.) were pioneers of the hybrid art of dance and the digital by designing technology for movement (Broadbent, 2009). Choreographer and media artist Johannes Birringer (n.d.), creator, director and coordinator of experimental platforms for performance-media design, such as Digital Cultures Lab, Live.Media + Performance. Lab at EMPAC and the international Interaction Lab have all contributed to the development of the Dance and Technology field. Birringer's performances introduced a different perspective on corporeal movement in relation to new media by exploring different aspects of movement perception. Susan Kozel (2007) with experimentation on movement and motion capture, Kirk Woolford (n.d.) mixes visual arts and technology to abstract the human body and patterns of bodily change, Boris Willis's (2014) interactive performances and games, Bebe Miller in *Landing/Place* (Miller, 2005) using motion capture as a choreographic tool. Golan Levin artist and software developer with interest of human body and motion, creator of *Interstitial Fragment Processor* (Levin, 2007) where participants can create shapes with their own bodies. Recoil Performance Group with *Body Navigation* (2008) based on infrared tracking and interactive video projections.

The list could easily expand since there are a large number of artists potentially in this group, and the list grows as more technology becomes available. The intention with this list is to illustrate the existing spectrum of explorations and research in the Dance and Technology field that use the technology to amplify the human body and kinaesthetic perception. A knowledge field that is often omitted in relation to the development of new technology.

One of the factors contributing to this development is the Open Source community that provided tools such as Processing, PureData, OpenFrameworks and Cinder (Creative Applications Network, n.d.), which create a platform for experimentation. Chayka (2012), in; *Software Development as Artistic Practice: How Open Source Is Changing the Way Art is Made*, describes the creative scenario and the artists approach to software development and Open Source sharing. ‘It's not just about making use of pre-existing platforms, but inventing new ones.
Groups of media artists are constantly developing original software tools that are made free to use and adapt.’ Furthermore, in the same context; ‘Rather than locking their

studio doors, media artists are in a constant, open dialogue over how, and how best, to make use of the technologies that drive their work. It's not just about making use of pre-existing platforms, but inventing new ones' (Chayka, 2012, unpaged).

In terms of the sharing culture, the creative approach to the technological development and the willingness to share, that often is visible in media art communities, contributes to an increasing number of artists beginning to work with computer code to make art. Consequently, in this scenario the combination of Kinect's open source development kit and movement based installations and artworks have rapidly increased, showing an innovatory approach and opening an avenue for applications that incorporate the human body in motion. During the review of movement-based art projects, consideration was given to the approaches that different artists use regarding the body as an input device as well as the different methods used for visual movement translation.

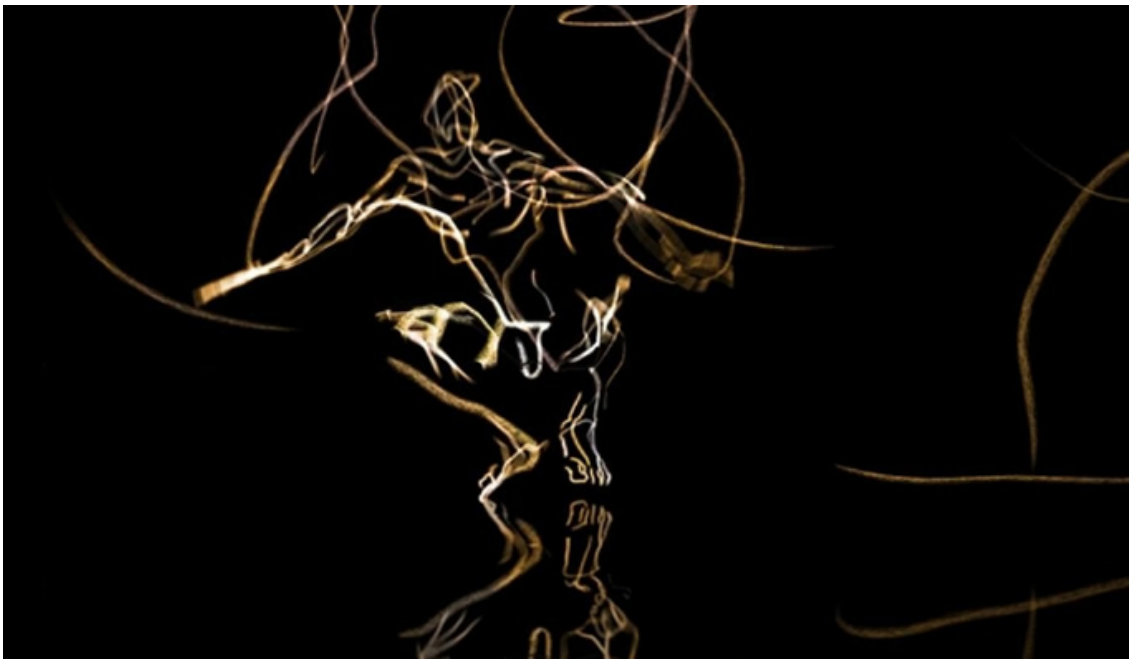

Figure 3.45 Ghostcatching, Jones *et al.,* 1999.

The installation *Ghostcatching* (Jones *et al.*, 1999) a collaboration between the choreographer and dancer; Bill T. Jones and two digital artists; Paul Kaiser and Shelley Eshkar, is a milestone in artistic explorations of corporeality, movement and optical motion capture technology. The digital body of Jones was presented as a 3D animated video projection, excluding the real body of the dancer during the installation (figure 3.45). The movements of the digital body were composed of brush drawn lines that generated new colourful brush strokes, accentuating movements, volume and direction.

The dancer became a painter, the body became a tool and movement became an exploration of three-dimensional space. Kozel (2007) cites *Ghostcatching* (Jones *et al.*, 1999) as an example when she reflects on the phenomenon of transformation from the real to the digital body. She highlights the duality in which we perceive the possibilities the technology opens to us. On the one hand there is fear, and on the other a need for confrontation with the visualised physical essence.

> When our data seems to perceive and act independently and at a distance from us, the composition and sanctity of the self is invariably called into question. For this reason, motion capture is a technology that makes some people fear for their physical essence and causes others to burn with the possibilities for extending what it means to exist as embodied beings (Kozel, 2007, p. 232).

Jones *et al.* (1999) formulated a set of questions as an artistic statement that emphasises the issue of the transformation between the real and the digital:

> So, we may ask: What is human movement in the absence of the body? Can the drawn line carry the rhythm, weight, and intent of physical movement? What kind of dance do we conceive in this ghostly place, where enclosures, entanglements, and reflections vie with the will to break free? (Jones, *et al.,* 1999).

The issue of absence of the body in a digital environment is resonant through my own investigation and led to the formulation of the following questions:

> How can whole-body expressions be visualised and transferred with the help of "The Digital?”
> How can emotion be explained in the context of corporeal movement in order to be measurable?
> How does physical data influence virtual data and how can we visualise such complex patterns?

During one of the experiments described in section 4.4.4 *Visualisation of Kinematic Data i.e. Emotions to Diagrams*, the numerical data received from the movement analysis tool gave rise to movement visualisations via charts. In this case the transformation is real but also symbolic, by transforming emotion into digits and then back again to a visual model.

Drawing on the experience of the *Ghostcatching* (Jones *et al*., 1999) project, the artists reflect my own concerns regarding what is left of emotion without embodied expression.

Performance practices that reconfigure the margins between the physical and the virtual are explored by Broadhurst in the performance *Blue Bloodshot Flowers* (Broadhurst, 2002), a combination of physical theatre, live art and new technologies. She exposes the technological development as a dialogue between the digital character and the audience. During the performance, actors and spectators interact with new technology through the emotions expressed by Jeremiah, a 3-D animated head with the ability to see and react to his surroundings. The technology in use was based on GeoFace software (Waters, 1987); providing predefined, scripted expressions for key emotions built into an articulated bone model, while the technology used for camera surveillance systems allowed the extraction and positioning of foreground objects (Bowden, 2002).

The technological issues investigated by me during the contextual research was the range of technical solutions available that could be used as a basis for comparative and reactive models. These included issues such as the accuracy of small-gesture interpretation, resolution, working volume, lag time, update rate and accuracy of joint location. These investigations were carried out before Kinect (Microsoft, 2010) was released. These explorations into technological solutions are not described here, but are visualised as an exploratory map, together with the PTM action flowchart: *Action Flow PTM & Related Material During The Contextual Research* (Appendix G). With the release of Kinect the studies focused on the development of a database that could be used with motion sensing devices. Kinect (Microsoft, 2010) developed as a device for an entertainment system, has been adapted by artists, hackers in open source communities and has led to many more creative ideas that build on physical movement.

A good example that demonstrates the future possibilities of motion sensing technology, such as telepresence and 3D motion capture, and places Kinect (Microsoft, 2010) in the context of art, dance and games is the installation, *Me and my shadow* (Hyde, 2012) presented by Joseph Hyde from Culture Hack, Scotland (figure 3.46).

The complete 3D 'capture' of the body, obtained via three Kinec*ts*, created colour-coded avatars (representing different country locations) controlled in real-time by the whole body movements of visitors. During this process, the data collected was compressed and sent over the Internet to four similar sites in other countries, allowing virtual interaction and feedback between visitors in the form of avatar projections.

Figure 3.46 Me and my shadow – 4 portals together, Hyde, 2012.

The movement characteristics of the avatars were previously developed in collaboration with dancers in Istanbul, as a part of a collaborative effort during four residencies by the artist in Turkey, Belgium, France and the U.K.
The development of the installation took place as a collaborative process that exemplifies cross-cultural and cross-disciplinary exchange. It is a part of Mobility for Digital Arts in Europe (MADE), as a collaboration between four art organisations: body > data > space in London, the Centre des Arts in Enghiens les Bains (Paris), Transcultures in Mons (Belgium) and boDig in Istanbul. The concept of avatars and telepresence can be elaborated in terms of public engagement. The emphasis of the project on interactive public installations has been of interest to the PTM project, in terms of the spectators reactions and the interest in spontaneous participation.

Another interesting project in an open public space is the interactive installation *Sniff* (Sobecka, 2009), a 3D projection of a dog in a storefront window that dynamically changes his behaviour based on the state of engagement of the passers-by (figure 3.47). It is a project by Karolina Sobecka, with software development by James George and uses a simple reactive system via video camera input (Sobecka, 2009). This installation was created with openFrameworks and Unity3d Game Engine that renders the dog in real time and allows behaviour, based on video tracking data, to change dynamically. The dog reacts emotionally to the movements of passers-by, which provokes a further reaction from the passers-by, changing their pattern of movements in order to prompt new reactions from the dog.

Figure 3.47 Sniff, Sobecka, 2009.

This is an example of developmental chain reactions that have produced playful and spontaneous behaviour from spectators within a public space, changing their movement patterns and provoking empathetic responses to a digital object. The artist describes her intentions with the installation as highlighting responsiveness and physical presence in the environment; ‘Sniff, simulating the visceral satisfaction of reality's responsiveness and dynamism, is also an exploration of engagement of two different planes of understanding, and of relationships created by body's presence in an environment’ (Sobecka, 2009, unpaged).

In terms of the PTM project, I was interested in systems built on predicted sets of human movements and the accuracy of the reactions that appear in a real-time situation. In relation to the idea of “body>data>body” *Sniff* is an interesting example. Following that, I was reflecting on the issue of spectators who at the same time become creators, and the possibilities that unfold with the development of motion tracking technology.

The dance group, Chunky Move in *Mortal Engine* (Obarzanek, 2008), under the direction and choreography of Gideon Obarzanek, explored the idea of the extended body in movement, using the interactive systems EyeCon and Kalypso (Weiss, 2008), and video motion-sensing programs designed by Frieder Weiss (figure 3.48).

Figure 3.48 Mortal Engine, Chunky Move, 2008.

The *Mortal Engine* dance performance builds on responsive projections, including video, music and laser, exploring corporeal movement and the unlimited digital body, where projected shadows expand the body's physical limits. Interactions between dancers, bodies and light are based on an infrared camera tracking system. The shapes, recorded and stored in the database, are projected as digital graphics refracted across the moving stage. The software used is: EyeCon (Weiss, 2008) motion sensing software, Kalypso (Weiss, 2008) and Open Sound Control (OSC) (Opensoundcontrol Org., 1997).

Analogously, the idea of the body as an architectural element that confronts space provides a different view on an expanded body, as explored by Oskar Schlemmer (1888—1943), one of the cross-disciplinary masters of the Bauhaus school. In his work, the body is treated as an architectural form that conveys the idea of an augmented body in relation to space and colour.

Schlemmer's experiments with the extended body in physical space embraced the concept of "affordance" sixty years before it was formulated by Gibson (1986). Therefore, his theoretical ideas, represented in his four works in figure: 3.49; *Man in the Sphere of Ideas* (1928a), *Egocentric Space Delineation* (1924) and *Figure in Space* (1921) and *Slat Dance* (1920) strongly apply to the virtual worlds and embodiments in virtual space, and could be specifically appealing for implementation in games.

The scale of the human being originates from the "self" into the scale of the physical environment (figure 3.49, top right) as well as in the opposite direction (figure 3.49, middle right) where the external space creates conditionaly factors for the physical body. These two oposits create a span resulting in that the entire body absorbing the environment, which in turn creats a sphere that umplifayes processing of abstract ideas (figure 3.49 left) .

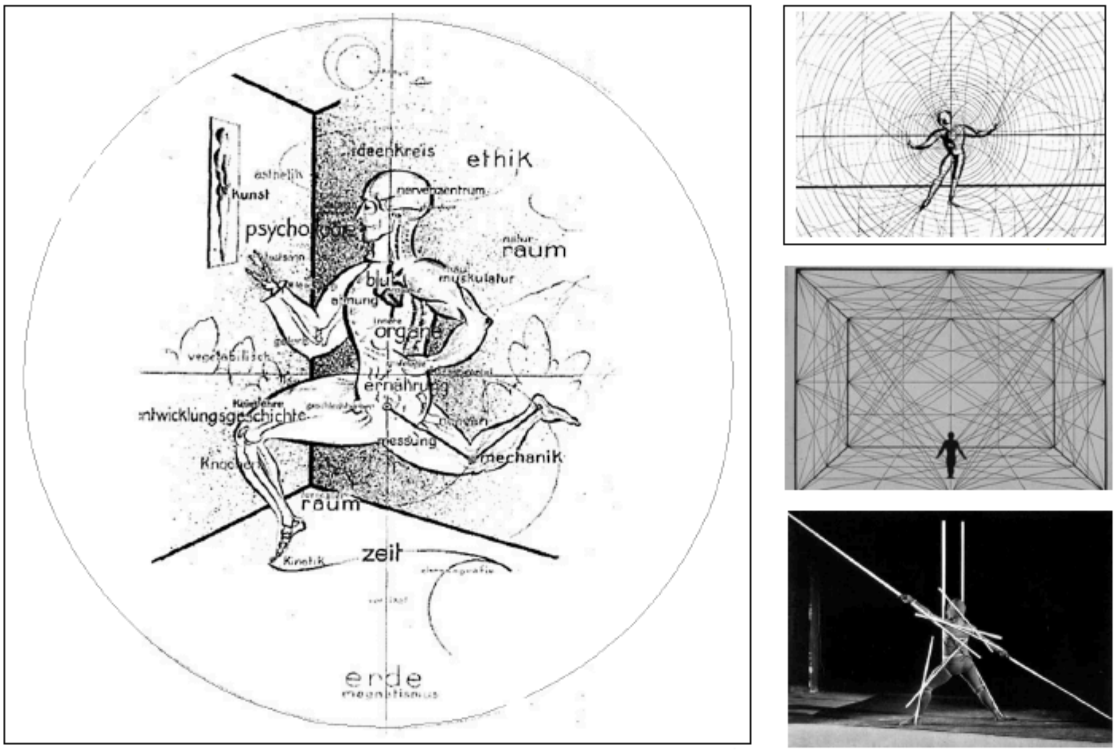

Figure 3.49 Schlemmer's work: Man in the Sphere of Ideas; 1928a (left), Egocentric Space Delineation; 1924 (top right). Figure in Space; 1921 (middle right), Slat Dance; 1920 (lower right) collage, Hrynczenko, 2009.

A parallel insight in context of the digital environment is highlighted by Norman (2006):

> Schlemmer's drawings resume our struggle to define relations to digitally wrought spaces. On the one hand, digital means are seen as positioning if not trapping us within grid-like spaces governed by the apparently inflexible abstract parameters of computation. On the other hand, digital affordances offer novel incursions into experiential spaces created by sensors, which draw embodied and digitally-generated percepts into a single loop. In the first instance, the heteronomous individual is seen as subservient to and determined by external factors, and in the second, the autonomous individual is seen as shaper and definer of his or her surroundings (Norman, 2006, p. 4).

Schlemmer's ideas link to an extended view of the embodied possibilities that emerge in virtual spaces, beyond the grid of x, y and z coordinates. Norman (2006) pointed out the existing possibilities of corporeal extension and fluidity via technological advancement where the expanded view is discussed from the perspective of the performer or user.

3.3.8 Digital Space From the Performer's Perspective

> *Dancing is movement in time and space; its possibilities are bound only by our imagination and our two legs. (Cunningham, 1968, unpaged)*

The technological advances widely discussed by the performance art community employed a new way of looking at the creative process.

> What may be qualitatively new today is the impact of increasingly complex computer technologies upon the human side of the production relation, that is on the psychology and perception of the performers themselves, on our physical experience and cognitive accommodation of multiple environments of work. (Birringer, 1999, p. 370).

Over the years, the discussion has continued through creative work, conferences, papers and forums where Birringer is often the driving force. Interviewed at Body Pixel, Birringer (via Hustic, 2011, unpaged) highlighted the need for further bodily confrontations with technology: ‘I think we need much more dynamic forms of interaction and the body emitting and perceiving, incorporating and excorporating.’

This issue is explored in the making of *Ukiyo 2* (DAP-Lab, 2008-2010), conceived and directed by Birringer. *Ukiyo 2* is a mixed-reality choreographic installation, based on the exploration of expressive gesture and rigid body movement that stems from an interactive system sensitive to the personal expression and intentions of dancers. ‘The system demands specific “performer techniques” and calibrations for the accentuation of kinaesthetic and kinaesonic gesture, movement and action’ (DAP-Lab, 2008-2010, unpaged).

Documentation videos have allowed me to build my own interpretation of this particular installation. In the contextual research, I follow a well-documented creative process, in order to see the whole picture of the performance creation, as I am interested in how the dialogue between the component parts forms around the issue of body, movement and technology in the process from the development of the idea to its complete realisation. My focus was on how the dancers incorporate the technology into the movement. *Ukio 2* is a good example, since this question is explored by both Johannes Birringer and Doros Polydorou (member of the DAP Lab, PhD researcher and interaction designer for *Ukiyo 2* performance) via the web-published dialogues (Birringer and Polydorou, 2010).

As Polydorou (Birringer and Polydorou, 2010) points out, the *Ukiyo 2* narratives are character-driven, referring here to the sensors that measure the average speed of the dancers' movement, which control the visual transformations on stage during the dance. In one of the conversations with the descriptive name, *Creation Scene, Action and Reaction* Polydorou has formulated a set of questions that mentions an issue that applies to many interactive performances in technology based situations.

> Q: Would the performer know what builds what? A: I am looking at this from the perspective of "would the character know?" The performer is taking the role of a character that has the ability to built [sic] the space. How does that character built [sic] the space? Would it improvise, dance, experiment and the place magically appears? Or would it coherently know and execute specific moves (magic? Spells?), knowing before the execution what each action will produce? I guess that if the performer knows, we are in a way forcing them to have a fixed choreography or at least certain fixed movements. Performers? What do u [sic] prefer? Do you want to know what each move does? Johannes? (Polydorou, via Birringer and Polydorou, 2010, unpaged).

Realising that dancers would prefer to know what each action would produce, Birringer has provided an elegant metaphoric solution in his answer, based on the idea of a performer as a painter facing an empty canvas, where movements could be used as a set of brushes fulfilling the wishes of the dancer.

> The main challenge was for a balance to be found between meaningful movements and the environment manipulation. As I understood from the feedback I received from the dancers, they prefer to know what each movement generates. I therefore needed to think of a suitable way to allow enough freedom to the dancer to performer their intention as well as being obvious to them what they are currently generating. So, going back to basic user interaction methods, I have thought of a simple brush system (Birringer, via Birringer and Polydorou, 2010, unpaged).

I have chosen this short dialogue sample as an illustration of methods and questions that should be considered when working with movement and technology on stage, but also content creation in games. Referring to the issue of presence, I consider that the technology deploys a dual action as an additional feature that extends the movement, which requires a training system for performers to be able to feel both as performers and as 'painters' at the same time. Extending the idea of the body as an interface in terms of "in" and "of" the body experience, the visual and kinaesthetic perception is amplified but may contradict the predominant patterns of the movement-execution process, if users are not trained. This may bring us to an intriguing philosophical reflection that tweaks the perception of the world and the kinaesthetic receptors.

In the physical realities of the real world, we use the movement of the body to relocate through the world, by changing the spatial position of the body or interacting with physical objects, or with other people.

The digital environments allow us to create the world as we move, adjusting the world to movements and character, as an opportunity for new experiences, but also an approach that confronts our perception. Often we prefer to fall back on the known patterns i.e. body as an interface to connect with the environment, rather than body as creator of the environment. Improvising further on this thought, I am attracted to Gibson's Affordance Theory as a way to approach the issue from a different point of view. In summary, affordance theory states that the world is perceived not only in terms of object shapes and spatial relationships but also in terms of object possibilities for action (affordances) — perception driven action (Gibson, 1977). This theory, based upon Gestalt theories, has implications in the digital environments and games, and is relevant in design, human-computer interaction, ergonomics, visualisation, and other fields. Norman (1988) has adapted the theory as a design model, explaining it in this way:

> ...the term affordance refers to the perceived and actual properties of the thing, primarily those fundamental properties that determine just how the thing could possibly be used. [...] Affordances provide strong clues to the operations of things. Plates are for pushing. Knobs are for turning. Slots are for inserting things into. Balls are for throwing or bouncing. When affordances are taken advantage of, the user knows what to do just by looking: no picture, label, or instruction needed (Norman, 1988, p. 9).

Firstly, there are differences between Gibson's (1977) and Norman's (1988) definitions of affordances. Simplification reduces the idea to interface design; nevertheless, it abides as a predominating interpretation in Computer Science and HCI design. As a parallel insight, important in this context, and an action-based understanding of the world, Corporeal Intentionality is presented by Leman (2008) in the context of embodiment and musical experiences, which I find relevant to movement-based digital space. He argues:

> …that corporeal intentionality can be conceived as an emerging effect of action/perception, couplings, the underlying engine of which can be defined in terms of a sensorimotor system. The engine turns the physical energies of music into an imaginary world of objects having qualities, valences, goals, and intentions, and vice versa. Corporeal articulations can be seen as expressions of this process of turning physical energy into an action-relevant and, as a consequence, action-intended ontology (Leman 2008, p. 84).

In conclusion, when the physical body becomes an agent creating its own digital environment, then the intentional and perceptive corporeal actions; "motor trajectories" open possibilities to unpredictable consequences for the "sensory trajectories" (Leman, 2008). This in turn could allow the development of a method for multipurpose, embodied actions as a tool. Furthermore, as Harrell (2009, p. 1) points out:

> Interaction in these domains should entail allowing users to affect the meanings in the story or poetic world they encounter, as opposed to merely manipulating virtual objects, navigating virtual spaces, or other purely mechanical modes of interaction (Harrell, 2009, p. 1).

This vision presents a more holistic view, where the digital world is not just a place to navigate through, but is taking into account the improvisation, imagination and poetic factors as a force to build upon.

When looking to the different interface paradigms rooted in principles of design and related to performance art and gesture recognition technology, is important to perceive and understand patterns rooted in human communication skills. This is the area of knowledge that belongs to Human Computer Interaction (HCI) and not a primary field of my studies, yet of high interest in terms of this research. The Human Computer Interaction field is highly interdisciplinary and includes a number of disciplines such as, psychology, social science, graphic design and engineering. Significant for HCI research are analyses of perceptual, communicative and cognitive processes, which provide the basis for future design models.

In the context of HCI, the idea to connect the PTM database with Kinect (Microsoft, 2010) has become an interesting option worthy of investigation. The idea is mainly based on the assumption that the PTM database could work as a reference for Kinect's movement recognition abilities. The assumption is based on a comparative method in which movement data input from Kinect based on bitmap or skeleton data could be compared either with the PTM's silhouettes directly as bitmap data or converted to skeletons. A possibility that was investigated in section 4.4.8 *Shape and Skeletons: Posture Comparison Process*

To document the idea, the interaction scheme between the PTM and Kinect and the possible outputs of the approach was created. I use an infographic as a visualisation method focusing on the interaction between the PTM and Kinect and the data execution processes. The principal idea with this visualisation was firstly to be able to quickly evaluate the different parts of necessary data flow, and secondly, to be able to present and discuss the idea's development with future collaborators. The Infographic is presented in Appendix D *PTM System and Database Infographics; a proposal for further development of PTM database with movement sensing devices.*

3.3.9 Physical Body, Emotions and Games

The contextual research encompasses several interconnected areas and in the case of this section, the investigation of virtual worlds and games in the context of emotions and non-verbal communication as based on gestures and postures. The focus in this part of the research is on behavioural patterns and their possible uses in game design.

In the scope of this study and from a performance art phenomenological perspective, some questions arise concerning how a game's content could look if games were also tools used to increase human perception based on human corporeal movement. Could the past century's knowledge, derived from pioneering performance and theatre work by Stanislavsky (1863 -1938), Gurdjieff (1866-1949), Meyerhold (1874-1940), Schlemmer (1888-1943) and Grotowski (1933-1999) be transferred into NUI and digital games? (Hrynchenko, 2010).

In other words, to produce embodied games, game designers may need to think outside their own “box”. It is a perception that several game designers would agree on. The two citations below relate to the posting; *The Contradiction Of Linearity* by Samyn (2010) on *Gamasutra, The Art and Business of Making Games*. *Gamasutra* (n.d.) is a site and international forum for the games industry, game developers and researchers in games. Samyn, a designer and developer, denotes in his essay the 'real-time nature' of games as a new medium, at which point he poses the question; ‘why games are so linear? He focuses on game linearity and as an answer, he proposes:

> A new artistic approach is needed to unlock the power of nonlinear entertainment. Writers need to stop thinking in prose and drama. The real-time medium is a poetic one. And game designers need to broaden their attention to the full spectrum of interactivity. We need to become painters of situations, architects of worlds, poets of the infinite, designers of the moment (Samyn, 2010, p. 4).

However, his answer concerns interactivity as a process connected to several phenomena of human creative nature in which he amplifies a need for a broader perspective. At the same time the linearity in games conflicts with the human process of decision making, which is strongly connected to emotions and physical actions. (Damasio, 1994)

In accordance with what is discussed in section 3.3.8 *Digital Space from the Performer's Perspective* my intention here is to connect the indicated concepts together by illustrating the same idea from two different perspectives. The apparent connection is noticeable in one of the answers to the Samyn (2010) article posted by Steward (2010), game design theorist, programmer and software project manager.

> Freedom of movement in more than one dimension gives the player a choice of directions to explore -- and that capability defines the playing space as an area or volume. It becomes a *place*, which requires defining the form of that space and the behaviors of the objects in it... in other words, world-building (Steward, 2010, unpaged).

In summary, examples of voices from the games industry are needed to illustrate the ideas and questions to which answers may be found in the field of Performance Art and Dance and Technology where the 'world-building' starts from the human body as the main interface. However, in terms of body-centred technology, the game development community, powered by growth in technical competence and audience range, have produced a valuable amount of research work related to human behaviour in these digital environments.

Katherine Isbister is an Associate Professor of Computer Science, NYU-Poly, a game and HCI researcher with a specific interest in social technologies such as embodied conversational agents and computer game characters. Her research (Isbister, 2006; 2008; 2011a; 2011b) highlights specific correlations and dependencies among emotions, movements and gestures, as socio-psychological connections, important to consider in the context of transitions of social communication skills in expanding digital configurations.

Isbister's work focuses on, as she herself describes it – 'social psychological and affective approaches to human computer interface, with special attention to games and other leisure and social technologies; embodied conversational agents and computer game characters' (Isbister, 2011a, unpaged). Her work encompasses a substantial number of research papers and books, some of which were important in the context of

my research questions as they relate directly to *Flowchart of Human Movement Classes* (Appendix I). Thanks to her engagement in issues of embodiment in games, her work has provided methods, analysis and the framework for understanding HCI design in games, which are extendable to other interactive digital environments.
Better Game Characters by Design: A Psychological Approach (Isbister, 2006) introduces and clarifies key concepts from psychology and social science, with key points on social communication patterns and body language. Isbister (2006) uses real-life social interactions to implement insights into character design with emphasis on the expression of a character's emotion, intention, and personality.

I have chosen to highlight a few insights that directly relate to body movement and expression since she relates these to social situations. Isbister (2006) divides body language into four categories: Distance, Touch, Imitation, and Posture. Distance corresponds to how far people stand from each other. The definition of Distance is based on the theory of *proxemics* (Hall, 1966) and is divided into four types:

1. Public distance (more than 12 feet)
2. Social distance (12 - 4 feet)
3. Personal distance (4 feet to 18 inches)
4. Intimate distance (less than 18 inches)

(Isbister, 2006, p. 145)

However, according to Hall (1966), human perception of space is patterned by culture. He suggests that people will maintain differing degrees of personal distance depending on the social setting and their cultural backgrounds.
Touch falls into four functional categories.

1. Function (a doctor's examination, or having one's coat removed by a servant)
2. Social ritual (a handshake)
3. Friendship building (friendly hug or a pat on the shoulder)
4. Intimacy (sexual interest or emotional connection)

(Isbister, 2006, p. 145)

Imitation arises when copying someone's posture or gestures. Usually this happens in group situations when participants mimic the behaviour of the most dominant person. Isbister describes four categories of posture with reference to Gallaher (1992). These are connected with the dominance and agreeableness dimensions of personality structure, and are affected by culture and gender.

1. Expressiveness (variety and energy in expressions)
2. Animation (energy in movement)
3. Expansiveness (occupation of space) — this is most strongly aligned with dominant personalities.
4. Coordination (smooth movement and grace)

(Isbister, 2006, p. 147)

This part of Isbister's research fills gaps in the previously constructed section 4.2.2 *Flowchart of Human Movement Classes*, particularly in terms of relationality, providing the groundwork for future investigations that also confirms whole-body movement and gesture as a highly important communication tools in social environments (Preston and de Wall, 2002).

During a Google Tech Talk, Isbister (2011b) presented her research about how movement affects social connections and our emotions. During the keynote *Emotion and Motion*: *Using Movement Design to Shape User Experience* she declared that concurrent with the increase of movement-based input–multitouch, stereo camera systems like the Kinect (Microsoft, 2010), accelerometer and gyroscope-enabled mobile and game controls — there is a much broader palette of choices for how people interact with information and interfaces. In this talk, she presented research about how movement impacts our emotions and our connection to others, and the implications of how we think about designing interaction with our systems.

Ibister (2011b) concludes (figures 3.52 to 3.55) that now is the time to establish new input conventions that will shape how we all use technology in the years to come. A statement based on her research findings that movement-based input introduces exciting opportunities for increasing engagement, reducing anxiety, and building social connections. Isbister points to several inherited human socio-cultural behaviours that are important to consider when designing games or other interactive applications based on human body movements. During her presentation she highlighted several potential problems that might arise when designing movement/gesture-based interfaces, that often are rooted in the tendency of designers to exaggerate coherency with reality, not taking into consideration the knowledge level and needs of the potential users. She used an example from the development of Dance Central (MTV Games, 2010) for Kinect (Microsoft, 2010), providing insights from the development process and reflections from the development team that fortunately realised their unrealistic goals and changed their way of production by working with their users, literally, on the dance floor. Another issue discussed by Isbister (2011b) was common mistakes by the designers, when the design is based on adjustments to computational logistics, which force users to have robot-like movements.

Figure 3.50 Emotion and Motion, Human acts like machine (screenshot), Isbister, 2011.

Referring here to Laban's principles of movement (Laban via Davies, 2006) these types of mechanical movements often produce stress in the participant. Isbister (2011b) exposes these robot-like movements (figure 3.50) as a level of discomfort that she recognised through interviews with participants, during research experiments at the Social Game Lab at NYU-Poly (Poly.edu, 1999).

Research at the Social Game Lab produces and uses evaluation tools such as prototype research games that allow the pooling of data for use in control comparisons. Furthermore, based on her social science research, Isbister (2011b) pointed to several underlying key factors rooted in inherited, yet partly unconscious, human communication skills. The essential elements of her research as summarised above, is the exposure of cause and effect in human bodily movements that have strong connections to emotions and human behaviour in group contexts.

Equally important in the context of the aims of my research, Isbister (2011b) has presented evidence of a reverse reaction, known as a physical feedback loop, which shows that movements can stimulate emotions and behaviours that, in intelligently designed games and other digital environments, can stimulate well-being and positively-charged social environments (figure, 3.5.1).

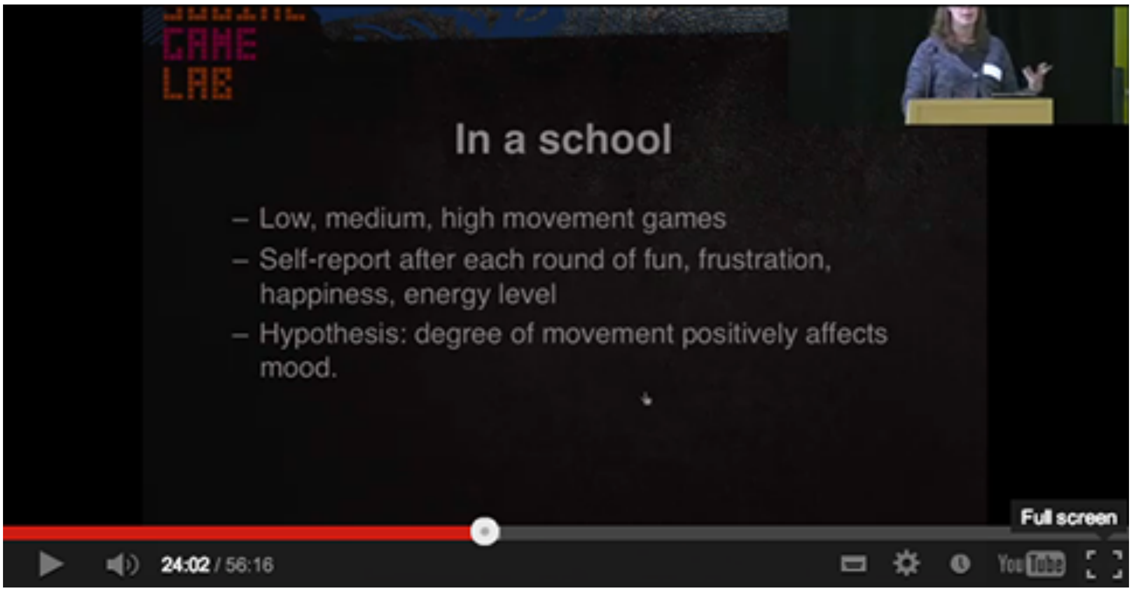

Figure 3.51 Emotion and Motion, Hypothesis presentation (screenshot), Isbister, 2011.

Her findings support the Facial Feedback Hypothesis (Havas *et al*., 2010) described in section 3.2 *Emotions, Science, Art and Virtual Worlds*. Isbister (2011b) concluded her presentation by pointing to the potential impact that the development of interactions via movement and movement-based interactive applications may have on society, education, academic research and games when encompassing already existing knowledge from other knowledge disciplines.

Ibister's research, conducted in a school environment and based on the hypothesis that the degree of movement positively affects the human mood opens a door to future possibilities for NUI. The research results indicate that movement affects the participants' energy level. However, no effect was shown for increased fun, frustration or valence (Isbister, 2011b). The analysis of effects on behavioural changes based on power movements and postures has shown that participants who used power positions have shown much higher tendency for risk-taking, which indicates an improvement of self-confidence (figure 3.52).

Figure 3.52 Emotion and Motion, Possible applications of the research (screenshot), Isbister, 2011.

One idea proposed by Isbister (2011b) is the Tai chi based interface for Gmail (figure 3.53) where users could navigate the mailbox using Tai chi movements. A point of view that applies particularly to my own interests and ideas.

Figure 3.53 Emotion and Motion, Tai chi for Gmail (screenshot), Isbister, 2011.

Isbister finalises her presentation by making several key points emphasising the importance of the research on human movements and gestures pointing at the correlations among movements, emotions, social connections and well-being. Isbister's key points:

- Know the science of movement and gesture.
- Be aware of what movement can provide.
    - Emotion
    - Social connection
    - Well being
- Push past the existing robot-like paradigm by valuing the moment-to-moment experience.

Isbister's (2011b) presentation has strengthened the idea of movement reversibility, i.e. that certain movements can awake specific emotions, and confirmed the research on emotions (Darwin, 1872; Havas *et al.,* 2010) reviewed in the previous section. Similarly, research in nonverbal behaviour studies (Cuddy, 2012), contributes to the notion of expressive movement reversibility as a means of therapy. Both studies presented scientific evidence that through body movement and posture, humans are able to control their state of mind, which provides a scientific grounding to Gurdjieff Movements' theory (Azize, 2012) embodied in the form of exercises used during the workshops and movement documentation phase.

It is possible to state that games based on whole-body movement are also of interest for game players. The research from Latitude (2011), specialists in studies on trends connected with new technology, has provided important statistical data (figure 3.54).

Latitude's (2011) study based on an online survey as a series of in-depth interviews with game makers and gaming enthusiasts has shown that:

- 71% of survey participants prefer to play games by gesturing or moving bodies.
- 53% will like to see the digital content overlaid onto the real world.
- 43% will like to play games that automatically senses and reacts to awake mood or bodily state. (Latitude via Situated Research, 2011).

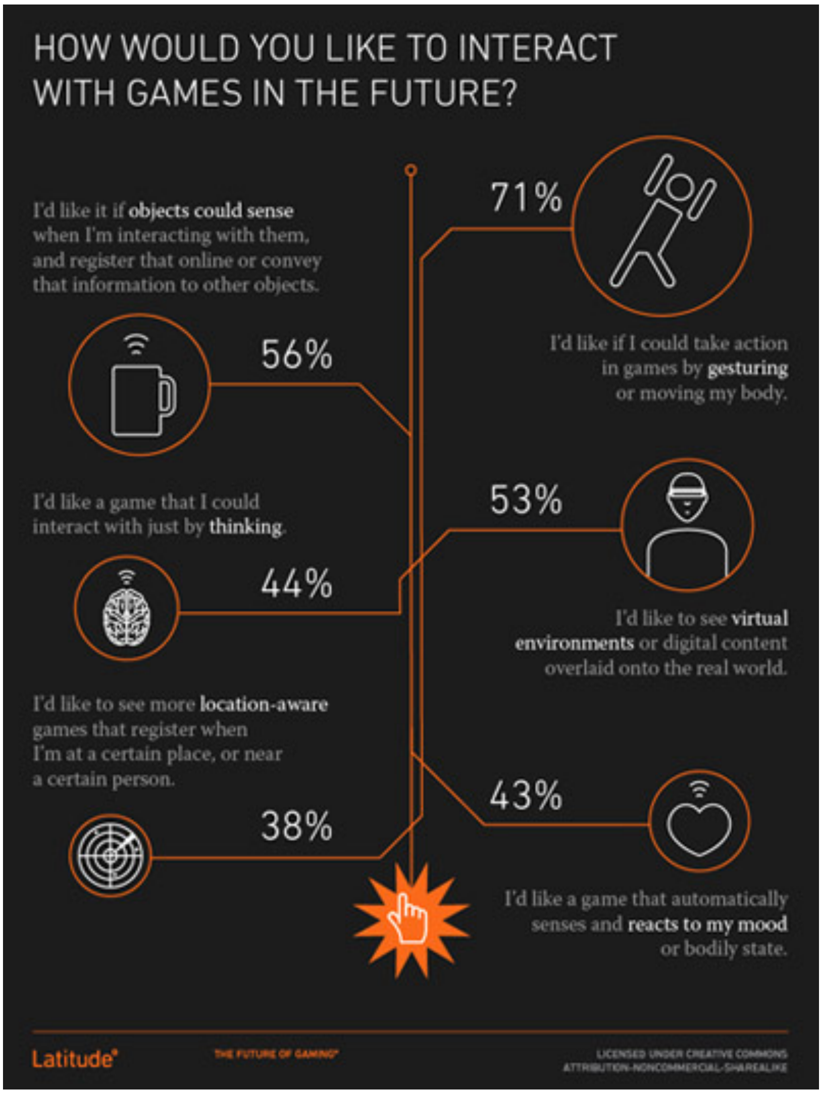

Figure 3.54 How would you like to interact with games in the future?, Latitude, 2011.

3.3.10 Conclusions

This section focused on both technical and artistic approaches connected to the PTM project, and defined vocabulary and formal semantics related to human-computer interaction, especially perceptual interfaces and movement recognition. In this context, several areas were investigated; presence in the body, emotive movements, visual representation, technology for body movements capture, body movement recognition and body movement interpretation in art. The contextual research has provided an insight into how art, and particularly performance art, could influence the design of interactive systems, highlighting the importance of systems that enhance the physical presence in the body that is equally important when playing a game, on the stage or within an installation. In this context, symbiosis between art and technology was highlighted and reflected as compatible with the early examples of research and practice

on the human body in motion from the beginning of the last century.
The issue of the body versus motion tracking technology was explored from the perspective of the art and dance stage as an open laboratory that provided examples of possible extensions or interpretations of the body in movement, and in case of the PTM project, worked as a source of inspiration. Furthermore, research by Ibister (2011a, 2011b) and Cuddy (2012) provided the insight that the PTM development has a possible application by using a feedback loop, as expressive movement reversed processes, allowing access to emotions as a method for rehabilitation. In this context, the contextual studies revealed that gamers prefer to use gestures when playing games. Referring to feedback loop (Ibister,2011a, 2011b and Cuddy, 2012), movement sensing technology is opening doors for a paradigm change in the way we look at the human body and expressive gesture in the context of digital environments. It is therefore extremely important that the tacit knowledge contained in centuries of performance art culture is incorporated into the technical development.

3.4 Database, Movement and Data Visualisation

> *Modern sensors increasingly tend to highlight intimate, inimitable features, the surreptitious rhythms and indices that are our hallmarks as living organisms, whilst rendering these same proofs of individuality in universally codified terms as digital data and the multimodal displays this data can drive. They entrain a telescopic collision between scales: the uniquely personal transformed into code becomes part of an indiscriminately generic, eminently reproducible database (Norman, 2006, p. 3).*

My attempt to collect expressive movements is a reflection of potential possibilities yet also of the advances accruing with the use of new technology, digital conversions and the (PTM) database. The idea of contributing with a collection of recorded emotional expressions has unfolded as a reflection on human vulnerability in digital environments. During the data collection and data evaluation process, I was using quantitative data, statistics and data visualisation as tools for my analysis, consequently resulting in an accentuated question: How to measure the emotion expressed by corporeal movement?

The objective of the expressive movement analysis was to recognise communicative patterns of emotional expressions via movement and postures. As a result of the analysis, similarities among expressive movements were discovered and a different level of the readability of expressions, however, it also became apparent that some generalisations materialized during the translation of emotions into data.

In this context, emotions are referred to as part of a human identity versus identifier; a term that in mathematics uniquely identifies something exactly. Accordingly, a logic question arose; ‘How much influence does identity have on the identifier?’ (Future Physical, 2003c).

The database is a system of data files provided with a navigable interface; a collection of information sorted according to set parameters that could be combined, supplying users with multiple choices. The PTM database is structured according to this design, as a visual collection of expressive movements extended with visual, numerical and statistical data and based on the qualitative and quantitative research. The last part of the research practice was devoted to the aesthetics of information related to the data visualisations used in the PTM database.
As an effect, during the contextual investigations I have chosen to focus on the database

as a creative tool and knowledge container, additionally increasing my interests to infographics and data visualisations as a possible representation of emotions.

This section reflects the possibilities and questions that arise with the use of the database, both in daily life and in contemporary art. Section 3.4.1 *Database in Art* explores the concept of a database through the critical eyes of contemporary media artists, defining at the same time the cognitive structure of the database. Examples of participatory art using database applications based on movement and gestures are exemplified in section 3.4.2 *Bridging Boundaries: Body>Data>Body*. Section 3.4.3 *From Data to Knowledge*, *Database as a Research Tool* is referring to the possibilities that arise with publicly open databases. Section 3.4.4 *Visualising Data*, explores data meaning via reflections on the convergence of art, code and data. Additionally, descriptions of the visual convergence of data provides an overview of techniques used during the research project and at the same time discusses the reliability of collected data in the context of the subjective view.

3.4.1 Database in Art

This part of the study investigates the intersection between real and digital modes of bodily representation and embodied actions, and the concept of the database, in the context of movement-based digital art and the new aesthetic it implies. According to research by Broadhurst (2007) and Maeda (2004), as well as theoretical formulations on nonlinear narrative spaces by Manovich (2001), the open form of the database is an unexplored potential for new artistic expression.

In my imaginary world, perhaps in this case built on semiotics, the term database always has associations with the picture of a tree, where the main structure was hidden in the roots in the base of the tree, and where the stored files become leaves on the branches as exchangeable, data items. These visual associations formed the “basis of the data”, where the trunk/body becomes a poetic metaphor for the interface. This vision does not build or define the real functions of the tree, or the database; it refers to the perceptive framework of associative and visual phenomena. In this case, tree is a symbolic metaphor expressing human desire for order also exemplified by the metaphor of the tree of knowledge used by Aristotle and Darwin and in many religions of the world as the tree of life. However, in reality, the world has a more interconnected and rhizomatic structure, as opposed to the genealogical structure of the tree. A metaphor of

knowledge as visualised and partly inherited from the *Encyclopédie, ou dictionnaire raisonné des sciences, des arts et des métiers,* (Encyclopedia, or a systematic dictionary of the sciences, arts, and crafts) (M. Diderot *et al*., 1751-1772.).
Deleuze and Guattari (2002, p. 15) commented on the metaphor of the tree of knowledge reflecting on the paradigm shift; 'We're tired of trees. We should stop believing in trees, roots, and radicals. They've made us suffer too much' concluding that 'the rhizome is an antigenealogy' (Deleuze and Guattari, 2002, p. 21).

These metaphoric and imaginative meanings illustrate how the idea of the database resonates in the word of *irreality*, a term defined by phenomenologist Edmund Husserl (1859 - 1938) as the subjective nature of experience that contradicts the life-world described by Husserl (via Natanson, 1973) as the unreflective, stereotypically accepted reality of the world.

When using the vocabulary of cognitive science, my imaginary detour could be described as a cognitive process based on visual, symbolic and associative models, often attributed to the Arts (Harrell, 2009), as opposed to the rational and quantifiable scientific. In fact, contemporary art is not divided between these two, but in fact comprises poetics, imagination, science, computer science, and engineering combined with political engagement and critical thinking. Connecting this thought in the social and cultural context of the rapid technological advances, I draw on the conclusion of McLuhan (1951):

> As the unity of the modern world becomes increasingly a technological rather than a social affair, the techniques of the arts provide the most valuable means of insight into the real direction of our own collective purposes. (McLuhan, 1951, p. 87)

The V2_, Institute for the Unstable Media (1981-2015), is an interdisciplinary organisation with the focus on research at the intersection of media art, technology and society. Through their activities: lectures, on and offline exhibitions, archives and publishing, V2_ encourages collaboration amongst interdisciplinary practitioners; artists, scientists, theorists and other researchers where the creative impetus as defined by V2 is unstable media:

> The word unstable is, according to us, more adequate than electronic, because it refers to one of the most important properties of the media, to wit, the rendering

> unstable of all things social, political, and cultural within our society—
> the unstable electron as a basic concept for our society (V2_ via Wilson, 2002, p. 862)

One of the V2_ publications, Making Art of Databases (Manovich *et al.,* 2003) is a collaborative work by Anne Nigten, Lev Manovich, Rafael Lozano-Hemmer and Brian Massumi, Joel Ryan, and Sher Doruff containing several essays.

In one of them, *Metadating' the Image*, Manovich (2003) highlights how the shift to digital media redefines the nature of static and moving images as a representation of new visual culture. He points at the availability of computed representations of visual data that provides creative opportunities for: 'new structure, new interface, new image, new scale' (Manovich *et al.*, 2003, p. 14). Nigten (2003) also describes the cognitive structures of the database, as functions based on two models:

> Metadata and content-management system design: the symbolic model and the connectionist model. These two approaches, including all their variations and branches, affect the way information is organized, annotated, stored and retrieved. (Nigten *et al.*, 2003, p. 9)

The specific structure of a database provides the possibility to combine and remix media files, creating new relationships and many distinct narratives that could be created from the same content. Paul (2007) points out that the existing, originally analogue, material can be explored in new ways.

> Art projects frequently apply the principles and logic of the database to existing, often originally analogue information—ranging from a book to movies, television series, and postcards—to reveal relationships that remain unseen in the original format' (Paul 2007, p. 101).

Flexible use of the database is a significant factor in terms of the creation of new types of narratives. The same database could be used in various ways with a different set of interfaces separated from the content, which could be exchanged or expanded, creating divergent objects, purposes and applications as Manovich (2001) describes:

> This formulation places the opposition between database and narrative in a new light, thus redefining our concept of narrative. The "user" of a narrative is traversing a database, following links between its records as established by the database's creator. An interactive narrative (which can be also called "hyper-narrative" in an analogy with hypertext) can then be understood as the sum of

> multiple trajectories through a database (Manovich, 2001, p. 227).

The concept of the database introduces new aspects of human identity, and at the same time we can see trends towards simplifications influenced by the way the database is used in our everyday lives. In the hands of an artist, new approaches are reflecting a renaissance of data meaning. In the *Introduction* to the *Database Aesthetics*, Vesna (2000, p. 155) points out the function of art and the artist in society: 'Archives and databases offer artists a vehicle for commenting on cultural and institutional practices through direct intervention'. Furthermore, she underscores the artist's role as a querying link between growing information flow and the aesthetic vision, and the continual need for a vigilant criticality:

> In an age in which we are increasingly aware of ourselves as databases, identified by social security numbers and genetic structures, it is imperative that artists actively participate in how data is shaped, organised, and disseminated. The collapse of the Berlin Wall, broken with the help of communication technologies, marked a beginning of collapse for many walls of categories. In this context, artists become information architects helping to usher in this new way of working, thinking, anticipating and helping to visualize new structures (Vesna, 2000, p. 155).

From the position of my own art practice, I found the concept of a database extending the possibilities of expression beyond my previous ideas, by providing the possibility of sampling data sets in a huge number of combinations' the artwork will never reach a complete and final state, based on the fact that the recipients are also co-creators. I found the maxim expressed by Weiner (1968) for conceptual art useful to clarify the case:

> 1.The artist may construct the piece. 2. The piece may be fabricated. 3. The piece need not be built. Each being equal and consistent with the intent of the artist, the decision as to condition rests with the receiver upon the occasion of receivership (Weiner, 1968, unpaged).

In the context of PTM, the users become a vital part of the narrative, and in the case of future planned movement based interactions, the content of the database becomes a trigger or response to the receiver's action. Harrell's (2009) *Toward a Theory of Phantasmal Media: An Imaginative Cognition- and Computation-Based Approach to Digital media* worked as a reflection point on digital media. His definition of *Phantasmal media* provided a theoretical foundation as well as a new vocabulary, such as *expressive computing* and *imaginative computational expression*. Harrell (2009) described *Phantasmal media* as research in imaginative cognition of formal approaches of cognitive sciences to semantics and semiotics in computer science, and cultural theoretic views of expressive discourse and media practice. The core focus of the *Theory of Phantasmal Media* is on the meaning and narrative of cognitive science and techniques for representing meaning and narrative applied through expressive computing based on a user-centred approach.

> Phantasmal media enable a range of new forms and genres of imaginative computational expression. Phantasmal media authors/artists can begin to think about their software in a new way–just as a goal of developing higher level programming languages is to allow computer scientists to think in terms of problems and solutions as opposed to algorithmic steps, a goal of this approach to expressive computing is to allow higher level digital media arts authorship where the author specifies a range of improvisational interactions to be meaningfully completed by a user rather than designing every interaction explicitly (Harrell, 2009, unpaged).

Manovich (1999) places the database as a symbolic form significant for the new cultural expressions of the digital age. He distinguishes the logic of the database as a system to collect and organise data that render a new type of narrative. The form of the database empowers the user to create his/her own narratives by using operations such as viewing, navigating, searching. In this way, the ‘linear perspective as a "symbolic form" of the modern age’ (Panofsky via Manovich, 1999, p. 89) leaves room for the ‘database as a new symbolic form of a computer age’ (Manovich, 1999, p. 89).

Database structure based on the user's choices is grounded on the same principles as physical navigation in the real world and becomes a feature of contemporary reality. Therefore, in the context of existentialism (Nietzsche, Lyotard), Manovich postulated that we should continue to develop poetics, aesthetics, and ethics using the possibilities the concept of the database provides.

With this in mind, I have chosen to refer to the web based chat and gaming environment; *Code Zebra* by Sara Diamond (2002) and Code Zebra Inc. It is a collaborative project produced on a cross-disciplinary, international platform, where art and science meet. The partners involved are Smartlab Centre, London, UK; V2, Rotterdam, The Netherlands; C3, Budapest, Hungary; University of Turku, Tampere, Finland and Future Physical, UK.

Code Zebra is a net-based collaborative communication system, used to collect, analyse and visualise communications. The project is analysing dialogue patterns for emotions, tones, mediation, role and game play. The structure is built on a modular system based on data processing modules (DPMs) that can request the data within a given volume of space (users, messages, relationships) add descriptions and values to the data objects and store them in the database. Integrated into the project is the idea of creating patterns of conversation that look like animal patterns, matching the organic in these patterns with those of the linguistic (Codezebra.net, 2002). Furthermore, *Code Zebra* integrates additional elements such as performances, installations and games as an extended tool. One of them, *Choreographies,* playing on the human tendency to anthropomorphise animals (Diamond, 2002) has some analogies with the PTM based on collaborative projects with dancers. *Choreographies* is an exploration of animal movements and voices using recited text from animal stories as independent narrative loops.

The main driving idea behind the *Code Zebra* (Smartlab, 2002) project was a need of dialogue between the worlds of art and science. The reason is explained by Diamond in the documentation of the process; Storyboards, Conceptual material, is an artist's vision of ‘the marriage between biology and technology’ (Diamond. 2003), exemplifying the artist's approach to a complex meter of convergence among different fields of knowledge.

> What do you mean? Amplification. Asymetry. Cellular Automata. Cohersion. Community. Complexity. Convergence. Continuos Variation.Decay. Decomposition. Diffusion. Feedback. Model. Morphology. Mutation. Navigation. Natural Selection. Network. Primitive. Reaction. Relational Materiality. Primitive: 'a polyhedral form used to construct virtual reality and 3D models on a computer'..Primitive: 'simple, uncomplicated, unsophisticated'…Primitive:, indivisible form of mathematical operation such as sphere, cube, addition, multiplication, or primitive life or pertaining to primitive indigenous or pre-literate people, or crude in construction' (Diamond, 2003, unpaged).

The third definition and the comparisons of the first two show conceptual links between social science, anthropology and computer graphics as well as pointing at cultural biases around primitive or pre-literate cultures.

During the keynote speech; *The marriage between biology and technology* at *Bio-Tech InterChange* (2003, Diamond), Diamond presented key points as key issues, thoughts, ideas and questions. These equally apply to the underlying ideas and questions of my own project. I quote some of these scenarios to illustrate the issues in the context of the PTM project:

> …Codes and rituals, …INTERIOR SPACES OF THE BODY, ...CULTURAL SPECIFITY, …OBJECTIVE/SUBJECT, …ROLE PLAY/FANTASY - key to transformation,… AESTHETIC CONDITIONS OF INVENTION, …ARTISTIC PLAY - unwelcome in science, …Art is about METHODOLOGY - immersion in making/critique of making'…Role of design versus role of art. Designer takes role of user' (Diamond, 2003, unpaged).

Bio-Tech Interchange (Future Physical, 2003) is a 'debate project and gathering point for professionals interested in delving deeper into the research area of bio-technology that involved a diverse group of participants working in/with biology, neuroscience, art, dance, music, video, web, installation, technology, cybernetics, genetics' (Future Physical, 2003).

Code Zebra (Smartlab, 2002) is an example of an early idea that uses novel, artistic forms and expressions intertwined with experimental spirit and produced as a cooperative effort between media art and science. Diamond (2003) highlights the need for cross-disciplinary collaborations, shared conceptual frameworks and new methods for communication between the artists, engineers, designers and scientists. Collaborations are in some ways analogous to ecosystems as reflected in *Code Zebra*. The above keywords, highlighted from the artist's point of view, provide a framework for understanding the scenario that leads to teamwork, highlighting the processes that facilitate cross-disciplinary interactions.

3.4.2 Bridging Boundaries: body>data>body

In a poetic way, I have tried to manage my visual and corporeal approach to the semantics of being "human" and the relationship to "technology" by merging both the old "input-->process-->output" database paradigm and the "flesh-to-flesh" concept of reversibility adapted from phenomenology into a symbolic statement: body>data>body.

The simple "input-->process-->output" (IPO) paradigm means that the database is mainly a big global variables store. The term articulated by Merleau-Ponty (1968, p. 127) "flesh-to flesh" is an expression describing the unity of the inside and outside, activity and passivity in relation to the world. In other words, a reversibility that works bidirectionally; a constantly ongoing interaction of the self through the body in the world. Perhaps similar paradigms can be used to tweak the name of the *body>data>space* (Bodydataspace, 2004),art/new media and design collective that is operating in the areas of performance, architecture, new media and virtual worlds, work which I highly respect.

Nevertheless, the idea of body>data>body has primarily evolved from the need to capture the driving idea behind this research in a few key words. As the name suggests, it refers to the action flow between two components: the biological body and the digital data. The interactions between these two create a bidirectional action flow in a "open loop" system. To demonstrate this process (body>data>body), the technical taxonomy used is; '...the whole-body movement/gesture style, enabling technology (input), application domain, system responses (output) and new whole-body movement/gesture style' (Karam, *et al.*, 2005, p. 1).

Within the context of this idea, the PTM database is a foundation for future applications of real-time whole-body movement interactions based on a comparative model. I have proposed a solution for the future construction that bridges the boundaries between the physical and the virtual. The ideas and potential uses are visually represented as a graph, *PTM System and Database Infographics; a proposal for further development of PTM database with movement sensing devices* prepared for future development and the potential cooperation with programmers, and described in Appendix D.

The main idea is based on the database containing the silhouettes in motion as both video and static images and input from users through Kinect (Microsoft, 2010). A set of algorithms will combine the input from Kinect with the material in the database in order to create a framework for expressive movement recognition, where the body in motion is the only interface. The goal is to enrich an embodied experience in order to amplify the cognitive system.

In my investigations, I have discovered that there is a large amount of research on expressive gestures, cognition and new technology in the field of music theory. The tools I have used in the analysis of movement are the result of research in this area. For this reason, it was important to discuss this research in the contextual review.
The previously mentioned art and media collective *body> data>space* (Bodydataspace, 2004), offers a platform for intercultural and interdisciplinary projects in the scope of

the human body, advancing the areas of technology, architecture and performance. Situated in East London, the collective creates and curates innovative media art projects promoting global exchange among artists and creators often in a form of experimental group projects both in real-time and networked digital environments.
Since their inception in 2004, the focus of *body> data>space* collective is on technology in the context of social, cultural and co-produced spaces, in which context, they have provided a creative framework for many artists; a space for creativity, and knowledge exchange.

The context of the body as a medium for new expressions and data as a tool to achieve them is highly promoted by the group of artists behind *body> data>space* (Bodydataspace, 2004). This approach created a new space for confrontations, experimentation and exchange of ideas. This is a space, which is essential to highlight and push forward a body-centered technical knowledge in the context of social and technological shifts.

The issue of embodiment in the context of action-body and cognition, is debated by Mazzola *et al*. (2012) where he exposes the missing link between embodiment and cognition, bringing back the discussion in a new iteration to the previously reviewed research in section 3.2: *Emotions, Science, Art and Virtual Worlds*. However, in this publication as the title explains; *Towards a Science of Embodiment,* Mazzola *et al.* are reflecting on an emergent issue that can be described as the need for more dedicated science. The core issues are explained as follows:

> We imagine a science whose core subject is the connection of the body — as it appears in an action-perception paradigm derived from mirror neurons, the embodied artificial intelligence (AI), and embodied theories of dance, music, and painting — to the cognition of emotions, language, mathematics and logic (Mazzola *et al.,* 2012, pp. 59-60).

In reflecting on the position of embodiment in modern science, Mazzola (2012), a music theorist and mathematician, encountered several philosophical and scientific hypotheses, which I found crucial to emphasise, beginning with Violi's substantial questions; '… what must be added to transform the body into a subject? And vice versa: in what way is the subject acting upon its body?' (Violi via Mazzola *et al.,* 2012, p. 69). Several points of view are outlined here as examples of distinct definitions of embodiment displaying the complex meter on which this research is conceived. Thanks to the progress of AI research, physical actions are recognised as a trigger for the cognitive process as stated by Pfeifer and Bongard (via Mazzola *et al.,* 2012 p. 60). ‘Embodiment is an enabler for cognition or thinking: in other words, it is a prerequisite for any kind of intelligence.’

Mathematician, Jean Cavaillè (via Mazzola *et al.,* 2012 p. 65) visualises the issue of presence stating that: ‘Understanding is catching the gesture and being able to continue’. Furthermore, Mazzola connects several theories with the cognitive mechanisms reported by neuroscience: ‘Perception activates the neurons for action, you continue the action when understanding’ (Mazzola *et al.,* 2012 p. 65). Combining this with the theory of common coding of perception, cognition, and action (Prinz, 1984) it can be claimed that these three intertwine the same code, a view also shared by James (1983) and Sperry (1952).

Mazzola *et al.* (2012, p. 70) continues: ‘In the vein of Donald's anthropological perspective, De Novellis considers the body's nonverbal communication as an embryonic form of high culture’. Mazzola completes the analysis with a new set of questions:

> Violi's discussion remains unanswered. How can higher cognition emerge from the embodied action scheme in humans? How can we describe the evolution of language, logic, mathematics, music, and other arts, from the action-perception cycles and mirror neurons? (Mazzola *et al*., 2012 p. 70).

As an effect of this discussion, in the context of Violi's questions, Mazzola proposes a tool set based on gesture analysis that stems from gesture theory in music. The tools proposed by Mazzola refer to arguments on the ontological mapping of the anatomy of a gesture as a reconfigured application of mathematical music theory by Hugues de Saint-Victor (Mazzola *et al*., 2012, p. 76) and specifically his definition of a gesture: ‘Gesture is the movement and figuration of the body's limbs with an aim, but also according to the measure and modality proper to the achievement of all action and attitude’. Mazzola *et al.* (2012 p. 78) concludes with: ‘Violi's subject may then be interpreted as being the identification of the body when the system of gestures operates in the creation of the ontology as mediated by Yoneda’s dilemma.’ This is based on the prior statement that, ‘…a mathematical object is completely known if we know how it looks when observed from all objects of the same type’ (Mazzola *et al.*, 2012 p. 77).

A couple of insights can be drawn from this discussion;

1) In order to understand emotion we need to understand the behaviour in the

context of a bigger system, and therefore, a set of multiple representations of the behaviour is needed in order to make associations, to measure and compare, and then observe the results from the context of the whole.

2) The concepts of embodiment have been researched and signified by others raising the concern for a marginalised, yet, scientific format of the phenomenon. In this context, the importance of action-perception cycles and the connection of mirror neuron research are highlighted.

3) There exists relevant mathematical theories for conversion and analysis of somatic movement and gesture where several tools have been developed through research in the field of music theory and composition.

Consequently, in the few examples summarised below I have continued to use the concept of *body>data>body* when viewing artwork that provides the opportunity for spectators to engage physically via visual data stored in the database. The final example: *Memory Release*, manifests this idea, yet, the focus is not on spectators as in previous cases. This example is an artist's comment on what occurs in the body and the brain during the embodied digital process.
As Munster (2006, p. 26) describes in her discussion on embodiment in the digital environment; '…individual bodies engage with digital codes to produce new and different sensations and affects.'

Originally, the idea in this section was to explore the relationship between the human body, corporeal movement and data interpretations of these two from the perspective of different contemporary artworks, where body or movement are converted to digital data and retrieved again in the form of information displayed to the artist or audience. However, as the PTM project evolved I became interested in the motives of the artist and concepts behind the artworks, performances and installations.

DarkMatr (Heene *et al*., 2009) is a project created by Tom Heene in collaboration with Pieter Heremans, Lionel Maes, Olivier Meunier, Lievn Menschaert and Dries De Roeck and Nadine/Plateau with support from science and industry.

The DarkMatr (Heene *et al*., 2009) project gathers artists and scientists who cross-examine alternative techniques to experience the Internet as we understand it today.

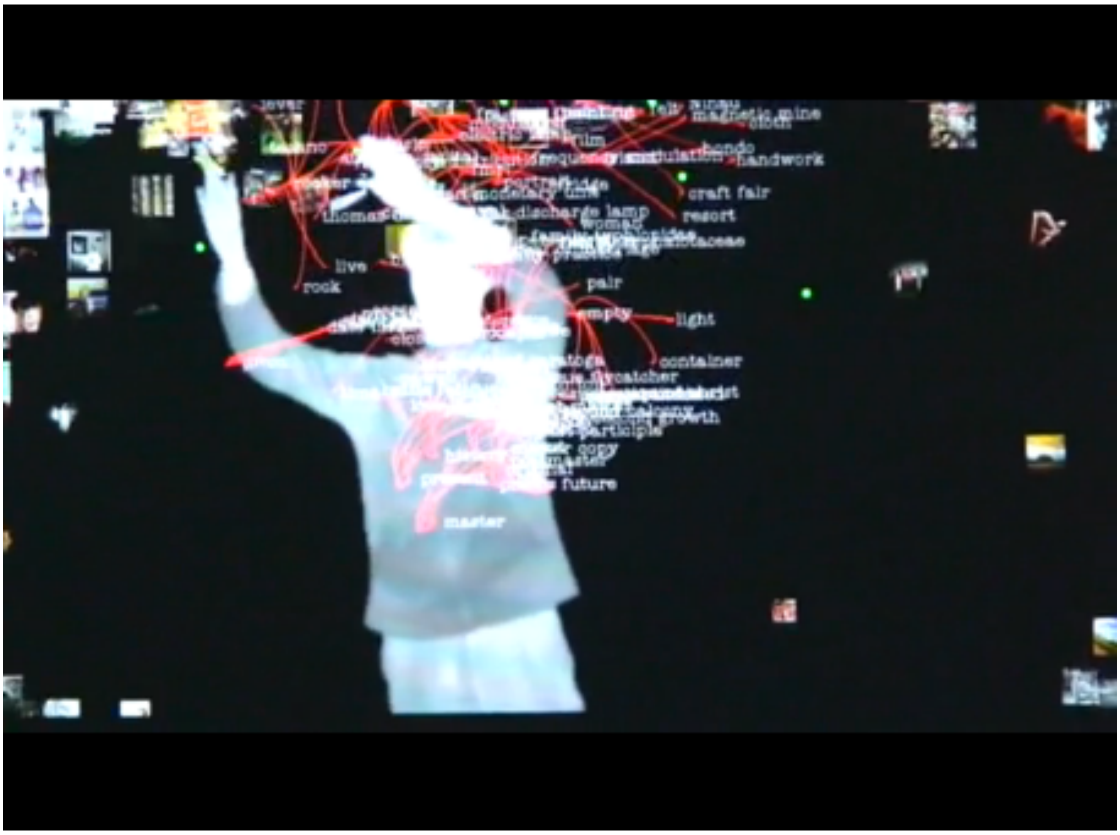

Figure 3.55 DarkMatr, Heene *et al*., 2009.

It is an interactive installation where the artists approach the web as a database for collective human intelligence in the connected age utilising a movement-based interface as illustrated in figure 3.55. The *DarkMatr* (Heene *et al*., 2009) project intends to incorporate the semantic technology of the web with whole body movements of spectators, where the user is part of the system through the surface of his/her whole body and interacts with web-based data such as, word-picture animations and soundscapes via gestures and movement. In this case, the user becomes part of a new data experience with an opportunity to physically control and respond to the information flow.

Artists have addressed a central question, which relates to my process of database creation: '… how physical data influences virtual data and how we can visualise such complex patterns?' (Heene *et al*., 2009, unpaged) This question was one of my own concerns; therefore, their working process was of particular interest.

The *DarkMatr* (Heene *et al*., 2009) project uses open source tools such as Processing (Processing Foundation, 2001-2015) and PureData (Puckette, 1996-2015). Both tools were particularly appealing in terms of the PTM. The study of the *DarkMatr* project development has provided insights into the possibilities that these tools could bring in terms of retrieving visual information from the PTM database in relation to corporeal movement. The intention of the *DarkMatr* project is to develop a semantic and audiovisual as well as a 'virtual-physical' environment in which people use their entire body to interact with the internet by retrieving data from wordNet (Miller, 1995), Freesound (Font *et al.,* 2013) and Flickr (Yahoo, 2005). Reflections on the development process are well documented.

My interest in this project was based on the need to compare functioning examples of databases navigated through the whole body movement, and the need to find answers to specific technical problems. Here, I was interested in examples where the data from Flickr is used in support of plans to use PTM database colour coding combined with the Flickr colour-based search engine. However, the main interest, in the context of my own research is based on the DarkMatr project's research on user experience as presented by artists:

> DarkMatr investigates the way data from the web and our physical world can be merged and presented in a total user experience. The installation uses representations that are recognizable for humans and which humans can empathize with. We are interested in how to visualize complex patterns generated from the combination of physical and virtual data (Heene *et al*., 2009, unpaged).

Similarly, artist Jiang (2012) investigates possibilities that exist in public space by engaging by-passers in tactile and physical involvement. Eyebeam (2011), the Art and Technology Center, where she is a member, presents her digital research and experimentation based on three parameters; 'open-ended involvement', 'participatory' and 'creative thinking' that I found noteworthy of mention.

> She emphasizes the autonomy of each participant to encourage open-ended involvement. Many of her projects are committed to a participatory model of creation. She believes in sharing the tools for artistic production as well as methodologies for creative thinking (Eyebeam, 2011, unpaged).

The project *Ideogenetic Machine* (Jiang, 2012), explores dialectical and dialogical relationships between the narrative thread and interactivity through the physical involvement of participants.

Figure 3.56 Ideogenetic Machine, Jiang, 2012.

During the *Ideogenetic Machine* installation (Jiang, 2012), a comic book was generated on screen based on the participatory engagement of the gallery visitors captured by a camera when they respond to a database of drawings algorithmically generated on the screen (figure 3.56). A dialogue is established when participants respond to artists' drawings through gestures and postures, leaving marks of their presence as characters in the comic book, filling computer generated speech bubbles with their own conversations. The *Ideogenetic Machine* installation provides the motivation for participants for active performance and collaboration in the situational conversations that as a result, create new narratives in a unique comic book.

Another project the *Figurative Drawing Device* (Jiang, 2008) is described as a study of 'relationship that is simultaneously invasive and intimate between two people' (Jiang, 2008, unpaged).

Figure 3.57 Figurative Drawing Device, Jiang, 2008.

The relationship is explored in the process of figurative posture documentation, where gallery visitors are invited to discover each other via their postures with the help of a drawing device (figure 3.57). The final artwork becomes a documentation of movement as Jiang explains:

> The imperfect line drawings preserve not only the presence of the person who was traced, but also the idiosyncratic movement of the tracer. Each drawing can be read as a graph which records the subtle psychological interactions between the two (Jiang, 2008, unpaged).

The drawings collected by the artists form a flipbook where they come to life, exposing the postures as silhouettes and the fragility of the line as graphs of presence in animated sequences. From the perspective of the PTM project, two aspects of the installation provide reflections; firstly the issue of presence is transformed to visuals in motion, as the silhouettes are used as a synthesis of fragile relationships between the live situations and scientific data. Secondly, Jiang (2008) investigates a method for collecting visual data produced by visitors as co-creators of the final animation, by providing a tool for participatory involvement.

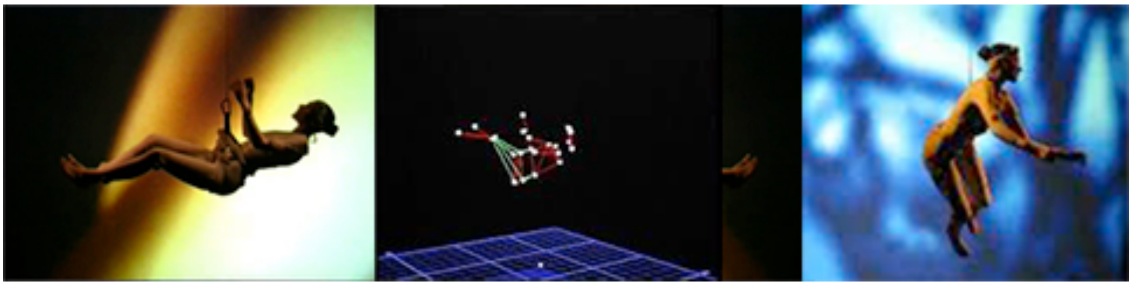

Figure 3.58 Memory Release, Rocamora, 2003.

The work of performance artist, filmmaker and choreographer Isabel Rocamora, is a fascinating journey into perception, emotion, human body, movement and gesture (figure 3.58). Her performance *Memory Release* (Rocamora, 2003), weaves together art, science and technology. Her concept differs from the previous examples since the concept of body>data> body applies here to the artist herself, as a body that generates and receives visual information without the involvement of public interaction. However, her work correlates and summarises the idea of the body as a memory container, therefore, in the context of the PTM I found it highly relevant.

The live performance, based on a video database and motion capture sensor technology, '…explores the mechanics of memory as understood by neuroscience and investigates the relationship between brain and body in the mnemonic process' (Rocamora, 2003, unpaged). As the author clarifies:

> As an anti-gravity artist I have spent the last ten years experimenting to push the boundaries of what the body in suspension is able to do. During these investigations one opens up areas of the body that were previously tightly held. At the point of opening one may feel the release of an experience, a memory, an emotion that had been housed in that area for years.
> …*Memory Release* aims to achieve, through an "external nervous system" (motion capture to computer, computer to projectors, projectors to screens) the so called mechanics of memory retrieval and release as partly described by Neuroscience and complemented by Eastern Medicine (Rocamora, 2003, unpaged).

In the performance, the artist's body is hanging inside a cube, suspended from a hip harness attached to 22 infrared motion capture sensors. These are located on the areas that correspond to an energy meridian that relates to specific organs, which in turn represents a specific emotion. The infrared receivers allow the motion capture system to map the body's movement in real time and turn it into raw data. Computed movement information is converted to commands via the programming tools and software that releases archived video footage (the memories) projecting these onto a screen.

‘The goal is to create an externalisation of the cinematic experience of memory through live movement editing. As the body moves, it remembers as it remembers, so it edits its memories’ (Rocamora, 2003, unpaged). Rocamora (2003) in the *Process notes* refers to the body parts and emotions based on Eastern medicine as a source of knowledge. This is highly interesting in the context of Gurdjieff's movements that refer to the same origins. Additionally, Rocamora (2003), based on her own experience and current studies in neurology, formulated questions that I found relevant in terms of the body in motion versus emotions:

> What is the process of encoding (recording) and releasing a memory?
> What is the relationship between body and brain in this process?
> Are memories housed in our organs?
> Is there a correspondence between organ, emotion and memory?
> Does the body in motion relate to that correspondence?
> (Rocamora, 2003, unpaged).

Racamora (2003) seamlessly integrates both performance art and science in her works. Based on current studies in neurology, she hypothesises that several parts of the physical body act as memory holders where she comments: ‘...a two way connection between the central nervous system (the brain) and the peripheral nervous system (the body) so that information may travel freely from one to the other via the connective highway – the spinal cord.’ (Rocamora, 2003, unpaged) Furthermore, in Eastern medicine, emotions correspondent to 12 specific organs of the human body, in reference to this Rocamora writes:

> Our experience of memory is often attached to an emotional state. It is interesting to imagine that certain memories might be located in certain areas of the body (It is said that the liver houses anger and the lungs are a storage for grief). Eastern medicine links those areas with detailed maps of energy points called the meridians. Body movement practices like Yoga or Tai Chi are based on that relationship (Rocamora, 2003, unpaged).

The artist's concept reinforces my own observations, verifying the importance of interfaces and applications that increase the corporeal experience. This example points to the research originating from the performance art sector, highlighting the embodied knowledge in relation to the contemporary findings of neuroscience and providing additional arguments for practice based research on explorations of human body movement and gesture. In the context of this research Rocamora presents conclusions that support the idea of movement reversibility.

3.4.3 From Data to Knowledge, Database as Research Tool

The predominant ambition with the PTM project is to contribute a development platform for future research on whole body emotional expressions, an open source database that could be carried out in non-uniform systems in research, art, animation and game design. With this in mind, I decided to follow the development of three projects as an investigation into the potential paths a database as a research tool can take. In the first project, I was fascinated by the multidirectional function of data from *The Visible Human Project* (U.S. National Library of Medicine, 2003) primarily developed as a medical and visual database of anatomically detailed images of female and male body parts. Thanks to the projects' open form, as a public digital archive, the making and re-making has rendered new artefacts and narratives beyond the scientific fields, influencing the work of artists and architects. The second project, *Dancers* (Blumenthal, 2009), the second project described, is a database containing video films of solo performances by professional dancers. In this case, the project was developed from the performance art sector with the intent to provide a platform for studies on dance and movement, highlighting dancers' perspective on choreography. The third project, *Synchronous Objects for One Flat Thing* (Forsythe *et al*., 2009) reconfigures the choreographical knowledge to another three-dimensional medium providing a new perspective on choreography, corporeal movement and the potential of data visualisation.

3.4.3.1 Science in Public Archives, a Platform for Making and Remaking.

The *Visible Human Project's* long-term goal was 'to produce a system of knowledge structures that will transparently link visual knowledge forms to symbolic knowledge formats such as the names of body parts' (U.S. National Library of Medicine, 2003, unpaged). The project was defined as a complete archive of detailed, three-dimensional images; a dataset of cryosections, CT scans and MRI scans, of "normal" male and female human bodies, which have continuously evolved over the years. It started in 1986 at the University of Colorado, under contract by the National Library of Medicine (NLM), after the corpse of 39-year old convicted murderer, Joseph Paul Jernigan, was donated to science.

The project was initially called *The Visible Man*. In 1995 the remains of a 59 year-old woman were released, introducing *The Visible Woman Project* (U.S. National Library of Medicine, 2003).

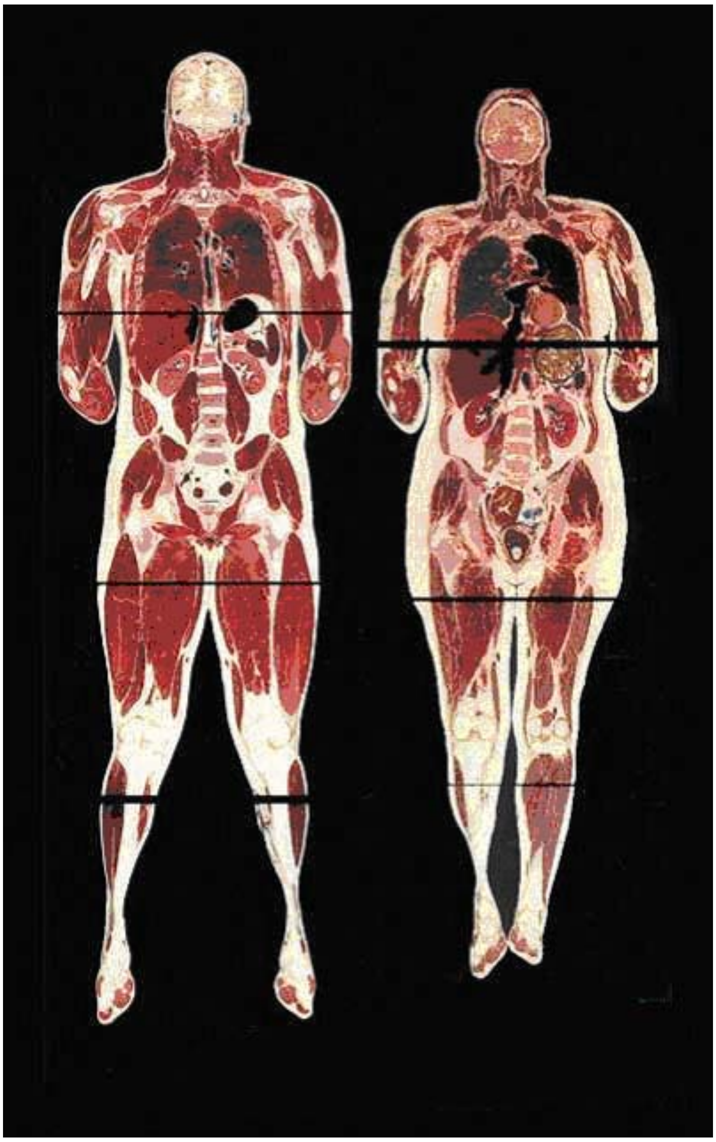
Figure 3.59 Visible Human Project, National Library of Medicine, 2003.

The data sets were frozen and digitised into 1 mm (male) and 0.3mm (female) spaced slices (figure 3.59) and generated over 18000 digitised sections of the human body, which converted to 30 GB of data for the male and 40 GB for the female dataset (Visible Human Server, n.d).

The availability of the visual data on the Internet provides new possibilities for both researchers and artists to use the data for research and artistic interpretations. The open structure of the archives makes it possible to explore and elaborate the data in different ways. Commonly known as “open data” it is rapidly gaining support, particularly from governments, science and digital arts reflecting a growing global participatory culture of media sharing.

The Visible Human Project, retitled by Danish newspaper Politiken, to “Download a cut up human being” (Den, 2009, unpaged) does not represent the complete picture, but rather characterises the reason why the project expanded beyond the areas of biology, medicine and techno-science over a short time, resonating in different areas such as education, scientific research, educational technology, medical imaging, biomechanical modelling, architecture and art.

My explorations during the contextual research over the expanded use of *The Visible Human Project's* data are illustrated in figure 3.60. The diagram showcases the impact of the archives in other areas of knowledge, since the examples described below do not completely represent the resonance the archives left in the fields of art, education and science.

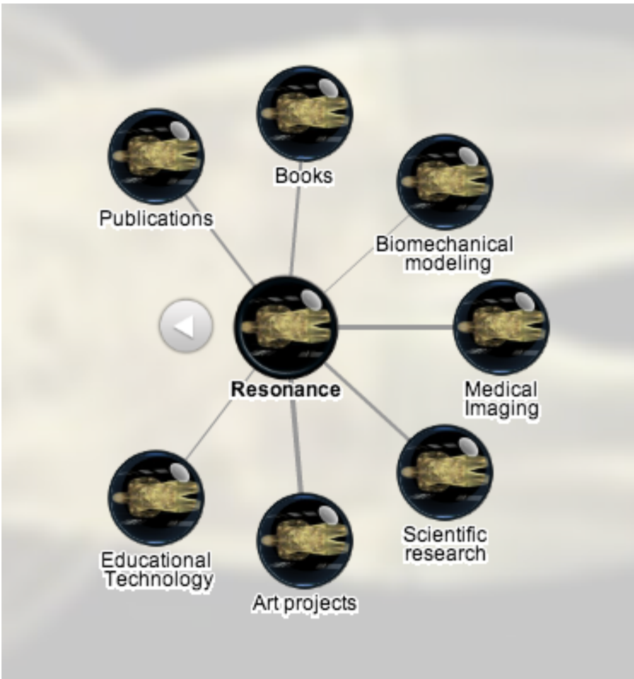

Figure 3.60 Screenshot, Resonance of Visible Human archives. Hrynczenko, 2011.

One of the related art projects: *I know you inside out* (Oliver, 2001) is based on the Visible Human archives exemplifying how an open public database can create a different use for the material, as opposed to its intended purpose. However, in the context of this specific project, Oliver highlights the vulnerability of the human body in a digital age. Her fascination of *The Visible Human Project* (2003) philosophically encompassing the idea of transformation; “body>data>body”, led her to symbolically reconstruct the human body using the digital slices and converting them to the analogue visualisation in a symbolic manner, back to the whole body.

> I was fascinated by the virtuality of the Visible Human – in becoming ‘visible’, Jernigan's body was converted from flesh to voxel: in order to create the dataset Jernigan's corpse was frozen and sliced so finely that it disintegrated to mush, leaving only digital photographs and scans. The images of his body where uploaded onto the Internet allowing him to be viewed at anytime and any place (but never all at once), he was under constant threat of being copied or translated. I downloaded images of his body and printed them onto sheets of acrylic and then put him back together again (Oliver, 2007, unpaged).

Figure 3.61 I know you inside out, Oliver, 2001.

In this series, Oliver's four sculptures represent both man and woman based on data from *The Visible Human Project* (2003) archive (figure 3.61).
Re-embodying the vision, she printed each image onto 3mm clear acrylic and hung them 2cm apart on stainless steel rods to recreate the image of the whole body.

In another artwork *Ornamental Transfigurations* (Al-Mehdari, 2008) based on *The Visible Human Project* (2003) the artist combines bio-spatial artefacts (figure 3.62) with the movement of the human body suggesting ‘…that a careful – even mathematically exact – study of human bodily movement could serve as a basis for generating new types of architectural form’ (Al-Mehdari via Manaugh, 2009, unpaged).

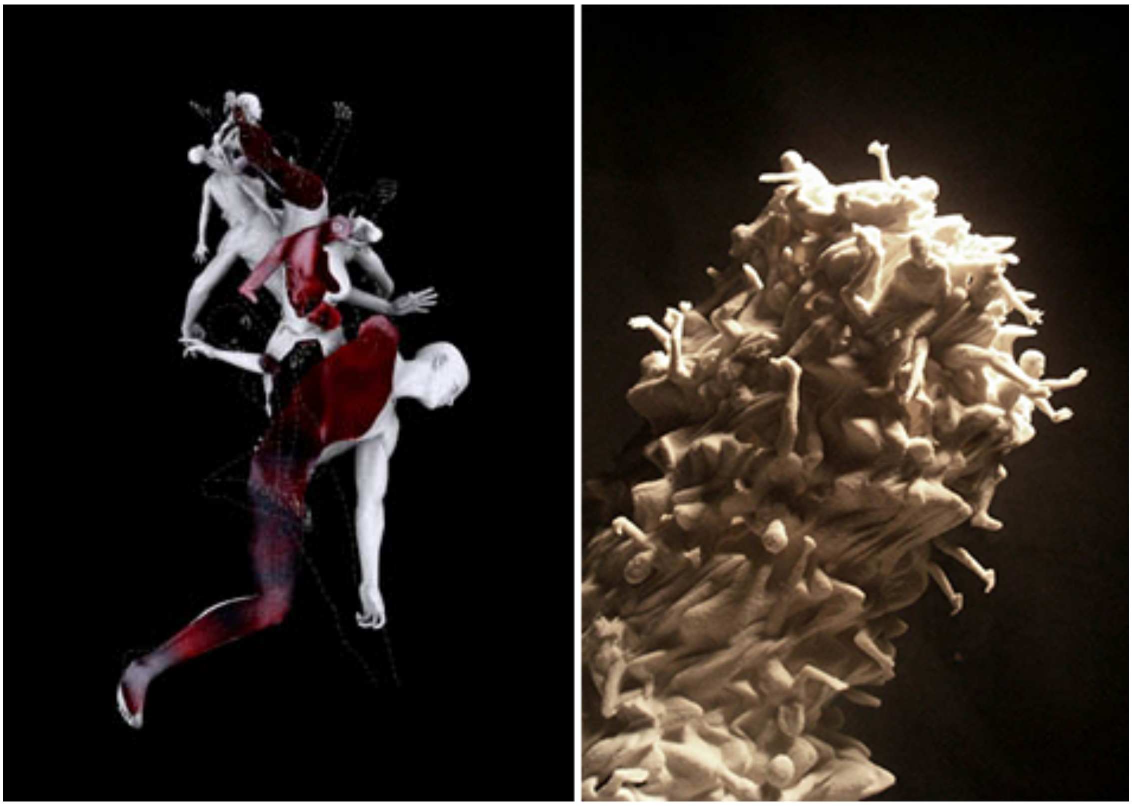

Figure 3.62 Ornamental Transfigurations, Al-Mehdari, 2008.

Using the *Visible Human Project's* reconfigured conical and cryosections as models, he searched for the ‘…visual and theoretical representations of the collective body’ (Al-Mehdari, 2008, unpaged) via computational methods that generatively intertwined biology with architecture. Futurist Geoff Manaugh, (former senior editor at Dwell magazine and a contributing editor at Wired UK) summarises *Ornamental Transfigurations*, pointing at the inquiries of a ritual as an important part of Al-Mehdari's work:

> The project explores religious ritual and the human body, alongside an interest in "transitory sculptures," processional routes, and a kind of body-futurist rediscovery of architectural ornament. Vortices of limbs ossify into cathedrals; overlapping anatomies become windows and valves (Manaugh, 2009, unpaged).

Al-Mehdari's work is not just a case of “making and remaking” the possibilities a public database could provide. I was likewise absorbed by the artist's perception of the collective body in the architectural space as a new way to see the body in motion, reinforced by the idea of ritual and captured in geometrical configurations of Baroque style aesthetics. The subject of ritual as symbolic interpretations of emotions and corporeal movement are debated in *section* 3.3.1 *Threshold of Presence and Space*.

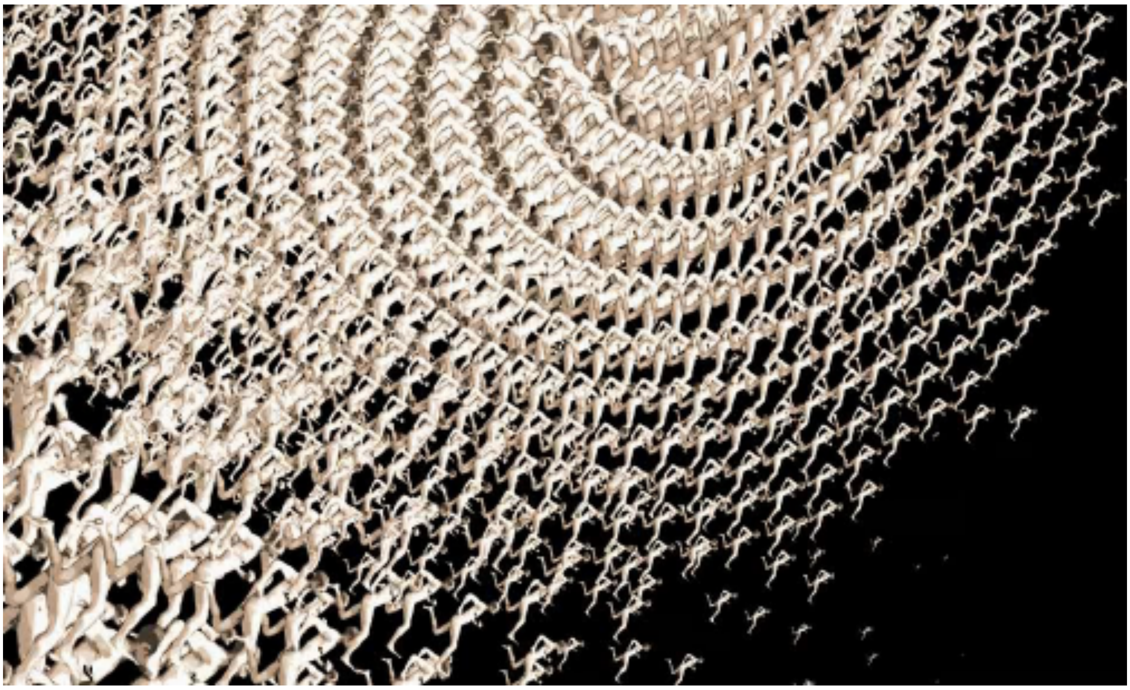

Figure 3.63 Invaders, Hrynczenko, 2009c.

However, the sculptural and architectonic vision of *Ornamental Transfigurations* (Al-Mehdari, 2008) becomes a cross-reference to my own inquiries. Both in terms of the similarities of the thought of the collective body, as well as in terms of the way I was repurposing film material previously created by Eadweard Muybridge (1830-1904). The animated film *Invaders* (Hrynczenko, 2009c) is inspired by Gina Czarnecki's work: *Spine* (Czarnecki, 2006), and *Nascent* (Czarnecki, 2005) especially in terms of the concepts of the collective body. The animation is based on the idea of the collective body as computed through two-dimensional geometrical patterns and created by ten lines of action script in Flash software (Adobe, 2009). I reused one frame from Muybridge's famous *Running Man* (Muybridge, 1887b) in an animation that repaints the running man on the screen in real-time in multiple geometric configurations. Figure 3.63 present a screenshot from the animation.

3.4.3.2 Transdisciplinary Research in Performance Art

The issue of transdisciplinarity is elaborated as an important part of knowledge transfer among disciplines, especially in contexts where new insights are produced for future technical development. As new needs emerge, the traditional concept of disciplines that divides knowledge fields requires new platforms that bridge the traditional boundaries. The project *Dancers* (Blumenthal, 2009) is a library of movement and personal choreographies published on the Internet in the form of an interactive database (figure 3.64). The aim of the project is to ‘put the dancer in the centre to demonstrate his/her art without having to adapt to the vision of a choreographer' (Blumenthal, 2009, unpaged). The interactive database is an effect of close interdisciplinary cooperation between Blumenthal (2009) and several research organisations that incorporate dance and technology. The technical solutions were designed based on an idea that came from the performance art field and was developed by programmers who usually work with databases for research in fields of anthropology, physiology and medicine (Blumenthal, 2009).

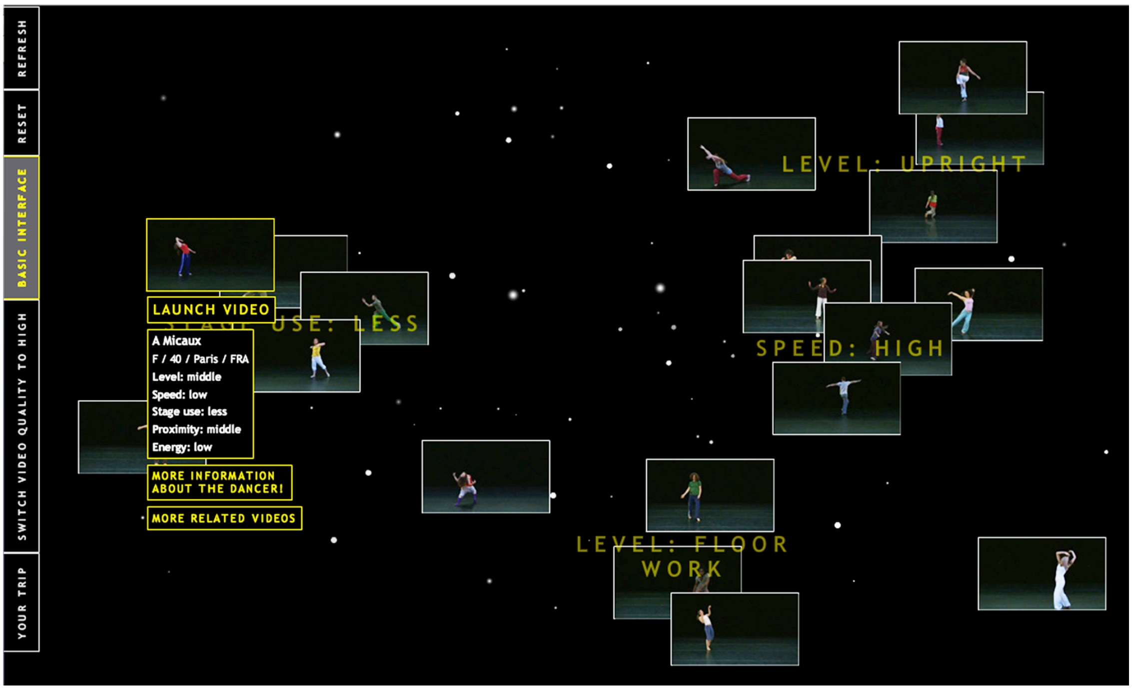

Figure 3.64 Dancers, Blumenthal, 2009.

Specific to the design of this database is a collection of personal choreographies performed by professional dancers of any style or technique for two minutes, in a defined space, with fixed lighting and their chosen music. The website *Dancers* (Blumenthal, 2009*),* contains the database of video films supported with a navigation interface providing multiple choices according to gender, music, age, country, technique, style and zodiac sign. In terms of the *Dancers* (Blumenthal, 2009) database as a research tool, the site supports relational navigation based on graphic constellations that can be navigated according to similarities between solo performances where digital analysis is used to find the correlations in the expressions used by dancers. The technology used for the analysis of similarities in the video footage particularly caught my attention, however, the software was developed especially for the project and is not available as open source.

Dancers (Blumenthal, 2009) is an impressive project that will continue since as Blumenthal assumes it will evolve within his life span. 'Its goal is to travel to cities throughout the world, and welcome dancers of all cultures into its database to join the collective project and form a vast community of artists expressing through their movement and gestures, their own artistic concerns' (Blumenthal, 2009, unpaged). The project is based on both qualitative and quantitative research methods where the dancers' personalised choreographical interpretations, are transformed to the data sets and visual objects stored in the database, which provides features for future comparative analyses through data visualisation.

Movement and data visualisation are explored in *Synchronous Objects for One Flat Thing* (Forsythe *et al.*, 2009), launched online in 2009 where the choreographic structures are explored, explained and visualised by transferring spatial movement of dancers' to data objects. The project developed through a cross-disciplinary approach where the output provides several data visualisation tools for capturing, analysing, re-imagining and presenting the movement of dancers in terms of volume and space. According to Forsythe, the aim of the project is to make dance accessible and understandable to the broader public.

The project was designed in collaboration with the Ohio State University Advanced Computing Centre for the Arts and Design and the Department of Dance, as well as experts in Architecture, Geography, Visual Communications, Computer Science and Engineering/Statistics. Cressie (2009), a statistics professor and the director of the spatial and environmental statistics program at Ohio State highlights this cross-disciplinary endeavour; 'As a scientist, I've always believed that science can be artistic. This is an exciting project, because I'm working with artists who believe that art can be scientific!' (Cressie, 2009, p. 1).

It is a historical cross-disciplinary breakthrough, which brings choreographic concepts into new areas of technology, transferring ideas of body movement into new media. Forsythe (2009), as a foreword to *Synchronous Objects for One Flat Thing*, discusses the position of choreography as an idea reflecting the issue of embodied expressions transferred to digital means.

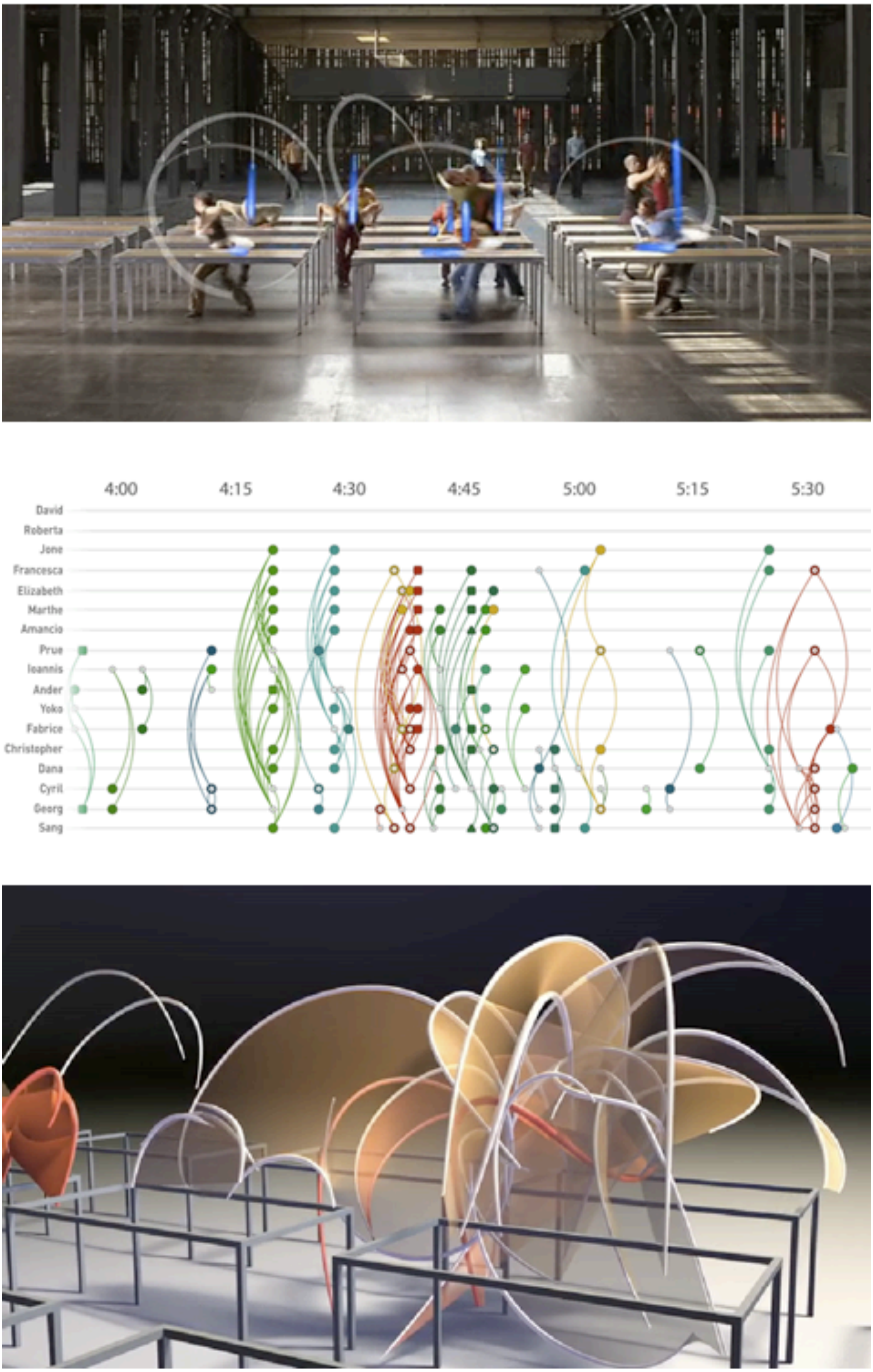

Figure 3.65 Synchronous Objects, Forsythe *et al*, 2009.

Analogously, Forsythe (2009) highlights the underestimated position of the physical body in western culture an issue to which I return throughout this doctoral study:

> But is it possible for choreography to generate autonomous expressions of its principles, a choreographic object, without the body? The force of this question arises from the real experience of the position of physical practices, specifically dance, in western culture. Denigrated by centuries of ideological assault, the body in motion, the obvious miracle of existence, is still subtly relegated to the domain of raw sense: precognitive, illiterate. Fortunately, choreographic thinking, being what it is, proves useful in mobilising language to dismantle the constraints of this degraded station by imagining other physical models of thought that circumvent this misconception. What else, besides the body, could physical thinking look like? (Forsythe. 2009, p. 1).

The project *Synchronous Objects for One Flat Thing,* based on artistic and scientific research, is visualising and remapping corporeal and spatial body movement into an accessible visual and digital language (figure 3.65). These transitions of media are highly relevant as an example of body movement deconstruction into the most basic level of binary representation and a source of inspiration in the context of this research project. The issue of data visualisation is represented in *Synchronous Objects for One Flat Thing*in a very extended way, proposing different data visualisations of the same actions, which provides a better understanding of movement as a choreographic object. *Synchronous Objects for One Flat Thing*is a successful example of a collaboration across knowledge fields and thus a pilot project that leads the way for future exchange of knowledge and methods amongst the fields of dance, performance art, visual arts, computer science and game design.

Several cross-disciplinary pilot projects are showing interesting outputs and synergies for creative development. The examples below illustrate interesting projects where art and technology merge creating innovatory outputs: Bauhaus: *Art and Technology – A New Unity* (1923), a part of the Bauhaus history from 1923 to 1932 where artists' creative output intermingled with technological innovation focused on architecture and design. In this context, the Architecture and Art education program 'examines how artistic design and design principles were incorporated in the teaching of architecture and how, conversely, architecture and society supplied themes for artistic design.' (World Wide Arts Resources, 1995, unpaged). Part of the project was organised under the direction of Oskar Schlemmer as an elaboration on movement and the human body. This explored the transfigurations of the human body into colourful figurative forms in the context of body and movement architecture, as a part of an architectural site.

Furthermore, a significant milestone in the history of the development of new technology was the famous *9 Evenings*, organised in 1966 by Experiments in Art and Technology (E.A.T) (Noll, 1994) as person-to-person collaborations between artists and engineers; an experimental method in the technological invention process.
In the same manner, the *Cybernetic Serendipity* (Cybernetic Serendipity Archive, 1968) exhibition that took place in London in 1968 experimented with cybernetic devices to make graphics, film and poems. *Synchronous Objects* (Forsythe *et al.*, 2009) experiments with choreographic structures translated to virtual 3D space, and a project that focuses on the physical body in motion; the Newcastle/Cambridge cooperation *Gesture and Embodied Interaction* is a project that explores motion-capture development from artistic, technological and business innovation perspectives (Norman *et al.*, 2010). These are just a few examples of the possibilities that reflect explorations of corporeal movement that coincide with the development of new technology and the database as medium.

3.4.4 Visualising Data: at the Crossroads of Object and Subject

Data visualisation is both an art and science, yet distinct approaches to visualisation exist within these two knowledge fields. When used as a method to visually represent scientific concepts and data, the scientist's focus is to communicate scientific findings or ideas. From the perspective of art, data visualisation is an equivalent of visual communication where the focus is on the aesthetics of information. These two perspectives are explored in this section from the common ground shared by both artist and scientist, namely, to communicate the unseen.

Throughout the history of art and science, both have influenced each other creating new techniques and ideas. New scientific and technical inventions produced new artistic ideas and styles. Scientific visualization of data, however, is an area where both objectivity and aesthetics meet. Visual representations of scientific findings provide visual cognitive support that can help in the analysis of complex data. Due to visualization techniques, complex scientific results can be communicated in a more understandable way based on the human brain’s ability to process visual information quickly.
Dulclerci *et al*. (2010) specify three main areas where visualization is instrumental: during *exploratory analysis*, where the data can be examined to draw new conclusions; during *confirmatory analysis* where arguments and hypotheses can be supported or

confirmed by visualization; during *presentation*, where the graphic image can illustrate the relationships, structures, behaviour or other characteristics related to the data. Graphical representations of data or concepts have undergone changes during the timeline of knowledge acquisition, both due to changes in the approach to the epistemic virtue and also due to technological developments. From the historical perspective, visual representation of scientific findings contributed to the distribution of knowledge and knowledge exchange. Diagrams, charts, illustrations, graphics and photographs, condense and simplify information without which meanings of scientific findings would be not possible to communicate or analyse. Similarly, blueprints, sketches, diagrams and maps have played an essential role in engineering, architecture and design as the pictorial form of concepts and ideas (Latour, 1986).

In this part of the contextual research, I investigate the convergence points between art and science by drawing on divergent concepts, techniques and an approach to knowledge acquisition. In this section, these issues are explored in the context of a philosophical and empirical point of view on the issue of subjective and objective approaches to the human knowledge of nature and the world.

The unity of art and science and especially engineering and architecture characterises the Renaissance where the terms art and science were practically interchangeable. Like many others of his time, Leonardo da Vinci (1452 - 1519), artist, scientist, architect, engineer and inventor, covered many areas of knowledge, one of them being technical drawing. However, his genius may not be visible to us if it were not for his technical illustrations, and sketches, notably since he preferred drawings over written words (Rogers, 2010). Looking at an example of one of his drawings that become influential in modern times; the *Vitruvian Man* (Da Vinci, 1492), extends the visual concept of the human body into philosophical and scientific thought. Notably, with the eye of an artist and mind of architect and engineer, Da Vinci by applying Vitruvius' (c. 80–70 BC - c. 15 BC) geometry measurements and anthropocentric thought, foregrounds a view on the human body as naturally created symmetry. However by extension of this thought, the concept of the universe become quantifiable and geometric. Da Vinci's concept of nature and of the world places the human at the center, as he references the *Vitruvian Man* as the '...cosmografia del minor mondo (cosmography of the microcosm)' (Rogers, 2010, p. 44).

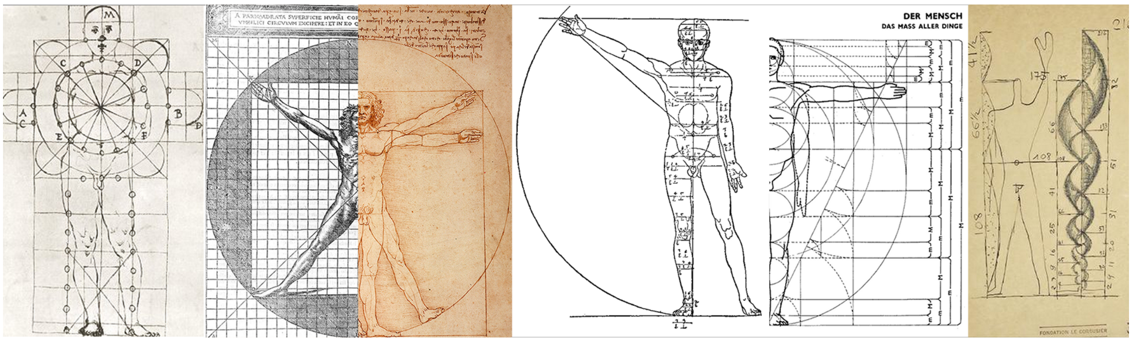

Figure 3.66 Giorgio (1470), Cesariano's (1521) interpretation of Vitruvius (15 BC), Da Vinci (1492), Dürer (1528), Neufert (1936), Le Corbusier (1948).

Da Vinci translated the concept of the human body placed inside a grid, which originated in an anthropocentric approach of Vitruvius to architecture. To some extent these influences could be traced to military architecture resulting from Giorgio's (1470) drawings (figure 3.66). Let us say, for the sake of argument, that the human body encapsulated in a geometric form evokes an idea of measuring and the measurable object divided from the rest of the world. My point here is; that image can convey information but can also contain philosophical ideas that influenced the Enlightenment's scientific approach that built the foundation for how we know the world today; the anthropometric concept inspired by *Vitruvius Man* developed through the centuries.

However, artists such as Leonardo da Vinci, Giotto, Donatello and Michelangelo were the driving force behind the increased focus on science, which was introduced through their own artistic endeavours. Geometric Art known for its shape perfection and symmetry was a characteristic of the ancient Greeks and Romans and served as inspiration for Renaissance artists, a phenomenon that also introduced interest in geometry, mathematics and architecture.

Pamela O. Long in her book *Openness, Secrecy, Authorship: Technical Arts and the Culture of Knowledge from Antiquity to the Renaissance* (Long, 2001), investigates the technical arts and the influence of craft and engineering on historical, scientific revolution through case studies including; Vitruvius (c. 80 BC – 15 BC), Francesco di Giorgio (1439 – 1501), Cesare Cesariano (1475 - 1543) and Albrecht Dürer (1471 – 1528). Long (2001) points at the connection of art, handcraft, and engineering to knowledge creation, in one of the cases, by referring to Cesariano. 'Cesariano brings together the rational and the mechanical in his discussion of machines…' (Long, 2001, p. 224). In addition, in the context of knowledge creation she argues via Cesariano the Renaissance's approach to knowledge: 'The ability to understand an object is associated with the ability to handle it skilfully. Nothing arises in this life except as a result of handling.' (Long, 2001, pp. 224). Furthermore in this context she writes:

> Cesariano praises the "noble philosophers" who invented machines. They are to be admired for their "understood contemplation," which preceded their "great knowledge." In addition, they are to be praised for their "burning desire to produce in sensible works with their own hands that which they have reasoned with their mind. (Long, 2001, pp. 224-225).

According to Long (2001, p. 247) the mechanical arts throughout the history of knowledge acquisition were used 'both to explore the natural world and to legitimate knowledge claims about that world'. The multi-layered connections between technical drawing, the philosophy of knowledge, engineering, and geometry, constituted during the Renaissance, created many re-interpretations of the geometry the human body. A few of the most intresting measurement scales that relate to the Vitruvius (c. 15 BC) concept were exemplified through the work of; Francesco di Giorgio (1470), Cesare Cesariano (1521) and Albrecht Dürer (1528), Ernst Neufert (1936) and also the modernist approach of Le Corbusier (1965). This was mainly, through Le Corbusier's interest in the anthropometric scale of proportions explored by him in the *Modulor* (Le Corbusier, 1948) as reffered by Cohen (2014) and Fischler (1979) (figure 3.66).

Continuing down the line of this historical perspective by reflecting on the distribution of knowledge and ideas, the Enlightenment was a period where the separation of science from art started to become evident. From the perspective of an empirical truth, the Enlightenment developed a worldview based on mechanistic physics, known as the Newtonian paradigm, which stated that mechanical, causal laws govern nature. This was an approach to nature introduced by Galileo (1564–1642) during the Renaissance (Russell, 2013). However, as a result, art and religion became separated from an epistemological approach to knowledge acquisition, grounded only in real and factual knowledge based on reason. During the Enlightenment, art was characterised by neoclassicism and later inspired during the latter part of 1700s to turn to romanticism focusing on interpretations of nature through a "sensible" imaginative approach. In the context of this period, the term "Aesthetics" was coined by Baumgarten (1739) and derived from the Greek word for "senses" as a science of what is sensed and imagined. According to Bristow (2011, unpaged): '...because for Baumgarten a science of the beautiful would be a science of the sensible, a science of sensible cognition'. However, in relation to science, art became more of an ornament in the service of scientific publications or a tool to depict scientific findings conceived trough a factual approach to the world. Voltaire reflects this approach by saying: ‘I value poetry only insofar as it is the ornament of reason’ (Voltaire via Furst, 1969, p. 19). However, in depicting scientific concepts the visual arts became the medium that reached a broader public.

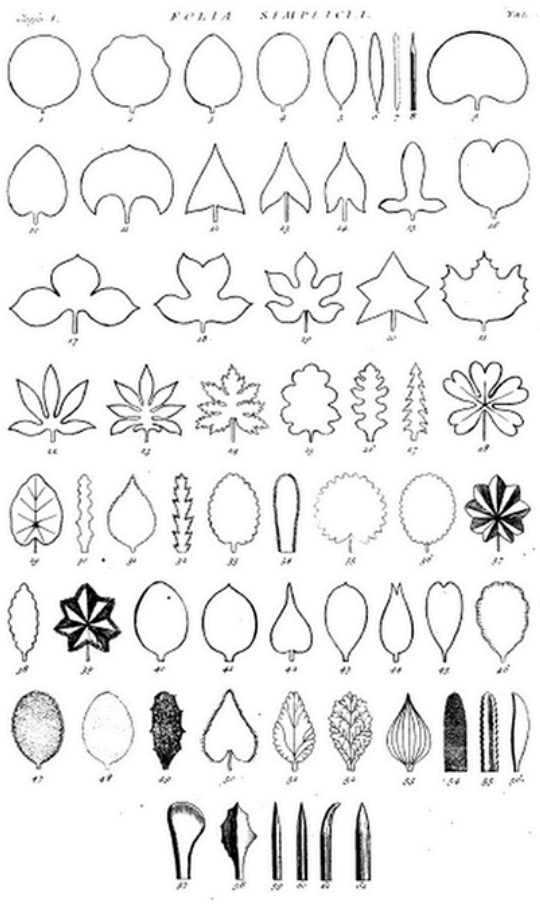

Figure 3.67. Types of Leavs; Hortus Cliffortianus, Carl von Linné, 1737.

For example, Carl von Linné’s (1707 - 1778) method for classifying and naming living organisms (Von Linne, 1735) may not have reached beyond a small circle of scholars, were it not for the engravings that illustrate his work. Especially since his work published in *Systema Naturae* (1735) was written in Latin and first translated to English in parts by Turton (Von Linne and Turton, 1802-1806). Linné‘s system to categorise families of fauna and flora is established on shape and structure and relies on an ocular and haptic knowledge. I use the same ocular and corporeal knowledge and the same cognitive approach for the categorisation of postures for the PTM database. Von Linné‘s botanic taxonomy became known to a wider audience in 1737 due to the illustrated atlas *Hortus Cliffortianus* (Von Linné, 1737) (figure 3.67) and through the *Encyclopédi* (Diderot *et al.,* 1751–1772).

The issue of conveying scientific knowledge to a wider public become one of the Enlightenments goals with the aim to change the world (Outram, 2006). The tool for this approach was the *Encyclopédi*, *or a Systematic Dictionary of the Sciences, Arts, and Crafts* (published in French: *Encyclopédie, ou Dictionnaire Raisonné des Sciences, des Arts et des Métiers*) (Diderot *et al.,* 1751–1772). Notably, it was a luxury product containing 17 volumes of text and 11 volumes of engravings with an array of illustrative information covering science, technology, and the arts. Published under the direction of Denis Diderot first in France between 1751 and 1765 and later complemented by several subsequent volumes and editions. By 1789, approximately 24,000 complete sets of *Encyclopédie* had been published, however, only the wealthy, upper classes of the European-wide audience could afford to purchase a copy (Lough, 1989).

Denis Diderot co-edited *Encyclopédie* until 1759 together with Jean le Rond d'Alembert despite their different viewpoints on science. D'Alembert following the ideas of Descartes maintained that true sciences like geometry should rely on 'abstract principles derived from reason'. On the contrary, Diderot supported 'experimentation and observation-empiricism as the best guarantees of reliability' (Magill, 1999, p. 5). *Encyclopédie* was the first publication that reached a broader public where science was represented by visual artworks on a large scale as an interface between society and knowledge. Based on both empirical and mathematical knowledge Diderot and d'Alembert organised the structure of the knowledge of the *Encyclopédie* together according to three main branches: memory, reason, and imagination. A system illustrated by a figurative system of human knowledge, inspired by Linné's classification method and charts and visualized the same way.

Visual artefacts as representation of scientific facts/data have a long record of controversy residing in the history of 'empirical virtue' and its connection to scientific objectivity (Daston and Galison, 2007). Objectivity from the philosophical point of view is associated with reality and truth in which truth is supposed to be unbiased and free from the influences of the observer. In other words, objectivity refers to the state or quality of being true, even outside of a subject's individual opinions, emotions, interpretations, and beliefs. In science, objectivity is a value that informs how science is practiced (i.e. the empirical virtue) and how scientific truths are discovered.

As image creation involves senses that are subjective in their nature, this conflicts with epistemic objectivity. Therefore, according to the conduct of epistemic virtue, the

human subjective influence on natural objects or phenomena and their representation should be suppressed (Daston and Galison, 2007). Nevertheless, throughout the history of the sciences, both formulations of the subjective and the objective and the distance between the subjective senses to the objects of inquiry have varied.
According to Daston and Galison (2007) the theory of objectivity could be partly traced to Descartes: “objectif” described as “a concept of representation of the mind.” (Daston and Galison, 2007, p. 206) and to Kant's epistemological provocation “objectively valid” and the “merely subjective” that acquire diferent interpretations (Daston and Galison, p. 207).

In the *Six Perspectives on the Object in Kant's Theory of Knowledge*, Palmquist (1986) explains several perspectives from which these different interpretations have arrived.

> Kant’s use of the word ‘object’ (Object or Gegenstand) is a potential source of much confusion and ambiguity. Sometimes he employes it as a general term either nontechnically to refer to ordinary ’thing’ which is met in experience, or technically to mean something like ‘a thing which stands in some kind of relation—potential, actual or necessary—to some kind of subject. Yet at other times he employs it as a more specific term referring to one or another of the particular stages in the proces of determining a thing to be an object (Palmquist, 1986, p. 122).

Palmquist (1986) provides the distinction in terms of Kant’s different perspective on the object: ‘*Throughout the Critique of Pure Reason* Kant makes frequent use of three object-terms (viz. ‘thing in itself’, ‘transcendental object’ and ‘appearance’)’ (Palmquist, 1986, p. 122).

In terms of the ‘thing in itself’ Kant (Kant via Palmqvist, 1986, p. 122) points out that these can only appear to us as a phenomenon that can only be investigated in an empirical inquiry; ‘...from a transcendental perspective, they should be treated in science as if they were things-in-themselves relatively to us as empirical beings’ (Palmquist, 1986, p. 122).

In the *Glossary of Kant’s Technical Terms*, Palmqvist (2004) presents Kant’s definition of objective as:

> *objective*: related more to the object or representation out of which knowledge is constructed than to the subject possessing the knowledge. Considered transcendentally, objective knowledge is less certain than subjective knowledge;

> considered empirically, objective knowledge is more certain (Palmquist, 2004, unpaged).

This new concept that juxtaposes objectivity to subjectivity emerges in the nineteenth century, as a reflection of an array of interpretations and misinterpretations of Kant's definition (Daston and Galiason, 2007).

Tarnas (1996) in his book *The Passion of the Western Mind – Understanding the ideas that have shaped our world view*, emphasises that '...the Cartesian-Kantian epistemological position has been the dominant paradigm of the modern mind...' (Tarnas, 1996, p. 433). Moreover, Tarnas reflects that through the history of epistemology the '…fundamental conviction that the relationship of the human mind to the natural world was ultimately not dualistic but participatory' (Tarnas, 1996, p. 433). From this perspective Tarnas comments on interpretations of Kant's subjective principles in regards to the human knowledge of the nature of the world;

> …but instead of considering these principles as belonging ultimately to the separate human subject, and therefore not grounded in the natural world independent of human cognition, this participatory conception held that these subjective principles are in fact an expression of the world's own being, and that the human mind is ultimately the organ of the world's own process of self-revelation (Tarnas, 1996, p. 434).

Daston and Galiason (2007) in their book *Objectivity* mapped the relationship between scientists and objectivity by analysing pictorial techniques used for the depiction of content in scientific atlases. The correlations in relation to the interchange of ideas between art and science that I aim to highlight, are partly built on the research of Daston and Galiason as related to objectivity in the context of the visualisation of data.

From the eighteenth through the early twenty-first centuries, methods used for scientific illustrations shaped both the subjects and the objects of science in which the approach to objectivity have been the main focus. Daston and Galiason (2007) could distinguish three different 'epistemic virtues' involved in methods of scientific data visualization: 'truth-to-nature', 'mechanical objectivity' and 'trained judgment'.
The first one, truth-to-nature-approach flourished during the Enlightenment. The methods often used to visually represent natural objects was 'actively select, sift, and synthesize the sensations that flooded the too-receptive mind' (Daston and Galiason, 2007, p. 203).

This empirical approach was, as previously referred to by Diderot, based on experimentation and observation. For example, as in Linné's work on the categorisation of the types of leaves (Linné, 1737), visual generalizations were employed requiring a balance between knowledge and intuition. This regulated subjective influence, such as interpretation was seen as an advantage. The 'genius of observation' (Daston and Galiason, 2007, p. 203) describes the-truth-to nature approach, they 'did not seek to depict exactly what was seen; rather, they sought a reasoned image' (Daston and Galiason, 2007, p. 98).

During the early nineteenth-century objectivity entered epistemic virtue in a modified version described by dictionaries as '...a reality in itself, independent of knowledge' (Daston and Galison, 2007, p. 206). In his book, *On Colour Theory*, (1810) Goethe, defines the relationship between subject and object as: 'Subject is the individual, in this case, beholder; the object, all that is without him' (Goethe via Daston and Galison, 2007, p. 207).

Throughout the nineteenth-century to know objectively was to suppress subjectivity, described as a 'post- Kantanian combat of the will with itself—what Schopenhauer called the will to willingness' (Daston and Galiason, 2007, p. 210). The development of photography became a new tool to depict scientific findings allowing the detachment of the researchers from the subjective self. A new scientific imaging took off, 'mechanical objectivity' where to avoid possible human bias, 'self-registering instruments, cameras, wax molds and other technological devices' (Daston and Galiason, 2007, p. 21) was used for depicting scientific results. The clear juxtaposition between science and art became visible in which the objective becomes defined as scientific and subjective as artistic. Interestingly, this approach provided a new and innovative techniques and solutions to depict scientific findings.

The third period, described by Daston and Galiason (2007) is a 'trained judgment', which in the twentieth century was a new way of depicting scientific data, a response to the previous empirical virtue ruled by mechanical objectivity.
The development of new instrumentations in scientific research required a new type of trained specialist, not only to operate any new apparatus, but to read the data, synthesise it and to make the correlations. The images of the collected data needed to be analysed, and the data identified and categorised. The new approach was characterized by trained

judgment where 'accuracy should not be sacrificed to objectivity' (Daston and Galison (2007, p 324). In many cases the data previously collected needed to be sorted, simplified and categorised in order to provide any useful scientific conclusions. Examples of data that needed this kind of procedure were x-ray radiographs and scientific photographs taken prior to the period of epistemic virtue i.e. the period of mechanical objectivity where the emphasis was on data production and less attention was given to data analysis.

In this regard, Galton's (1878) composite photography is a useful example. Galton used composite photography by overlapping photographs of faces to illustrate his argument on genetic traits, which according to his eugenics research shows differences of moral integrity amongst human races. Wittgenstein used Galton's technique with a different approach, and could provide a different perspective on Galton's eugenics (Daston and Galison, 2007). Wittgenstein, by blending together faces of whole families demonstrated a linked network of common features across many human faces. In aiming to show deeper meanings that could be conveyed by a visual expression, my focus here is on Wittgenstein's approach to "probability" contained in what he calls the photography of "fuzziness" (Nedo, 2011) explained as a foreword to the exhibition, *Wittgenstein's camera*, (Wittgenstein Archives, 2011):

> A photograph is a frozen moment, outside time. As Wittgenstein says it is 'a probability', not 'all probabilities', what one sees in the blink of an eye. But if you keep your eyes open you will see things move and change, nature as a dynamic event, and it is this constant changing that creates fuzziness on one hand but clarity on the other, because if you only glimpse then you exclude all other aspects, you have no greater clarity, you are blinkered. (Wittgenstein via Nedo, 2011, unpaged)

The idea is condensed in his statement: 'Don't think, look!' (Wittgenstein Archives, 2011, unpaged)

During the research, I used digitally simulated x-ray techniques, which produced several series of images derived from 30-second video clips that represented the emotional expressions of 19 people. For each video, all the frames were mechanically blended together using a composite technique. By mapping traces of gestures and movement into one frame, the volume of movement connected to each embodied emotion becomes visible. This approach simulates the 'mechanic objectivity' where my aesthetic point of view is detached from the production process. However, the results of this experiment are evaluated visually in order to find similarities among the expressions of four emotions: anger, fear, joy and, sadness.

> The sage who sought truth-to-nature cultivated memory and synthetic perception; the hardworking hero of objectivity steeled the will to resist wishful thinking and even mental images; the-self confident expert trusted to judgment informed by well-schooled intuitions. All images—whether rezoned, mechanical, or interpretated— bear the marks of epistemology and ethos. (Daston and Galiason, 2007, p. 363).

Daston and Galison (2007) highlight that there is a relationship between observer and observed in depicting science. Namely, that epistemic objectivity it is a tool to regulate the moral scientific-self, however, it should not be seen as an instrument to describe the absolute truth of reality. However, visualising knowledge or phenomena, besides the instrumentality of the image as a tool of representation, it provides the possibility to support and convey arguments. Specifically in terms of diagrams, charts and models which are often used as the only instrument to show patterns of specific phenomena. Latour (1986) in *Visualisation and Cognition: Thinking With Eyes and Hands*, critically analyses knowledge acquisition, knowledge exchange and the external and internal politics of knowledge.

Latour (1986) by referring to visual perception, pointed out that depicting knowledge in two-dimensional space, both historically and today, plays a major role in knowledge acquisition.

> There is no difference between natural and social science, as far as the obsession for graphism is concerned, if scientists were looking at nature, at economies, at stars, at organs, they would not see anything. [...] Scientists start seeing something once they stop looking at nature and look exclusively and obsessively at prints and flat inscriptions. In the debates around perception, what is always forgotten is the simple drift from watching confusing three-dimensional objects, to inspecting two-dimensional images which have been made less confusing (Latour, 1986, p. 16).

The issue of representation of three-dimensional objects in two-dimensional space is, one of the values of depicting science reflected by Latour (1986):

> The two-dimensional character of inscriptions allow them to merge with geometry […] The result is that we can work on paper with rulers and numbers, but still manipulate three-dimensional objects “out there” (Ivins, 1973). Better still, because of this optical

> consistency, everything, no matter where it came from, can be converted into diagrams and numbers, and combinations of numbers and tables can be used which are still easier to handle than words and silhouettes (Dagognet, 1973). You cannot measure the sun, but you can measure a photograph of the sun with a ruler (Latour, 1986, p. 22).

Latour (1986, p. 22) calls this opportunity the 'second-degree advantage' of an image, 'a surplus-value gained through their capitalization'

However, looking at charts and diagrams, as a visual representation of data, the line plot, pie chart and bar chart was first introduced in the eighteenth century by William Playfair (1759 – 1823). His invention created the groundwork for the future development of the visualisation of statistical data (The Encyclopedia Sponsored by Statistics and Probability Societies, (n.d. a) Similarly, the statistician and founder of modern nursing, Florence Nightingale (1820 −1910) contributed to data visualisation development with her inventive circular area graph used by her to illustrate unsanitary conditions in hospitals. The graph used in the Report of the Royal Commission supported her argument by demonstrating that more soldiers died of infections than on the actual battlefield during the Crimean War (The Encyclopedia Sponsored by Statistics and Probability Societies, n.d.,b).

During my explorations of techniques for data visualisation, both plots and circular charts are used to make sense of large quantities of data, especially during the visualisation of data received from movement analysis and during the evaluation of movement recognition. In the context of movement visualisation, a visual display of data was necessary in order to find patterns specific for each of the emotions collected from video clips, in terms of the quantity of motion (expressiveness) or x and y coordinates (movement space).

At a Technology, Entertainment and Design (TED) talk, *Stats that reshape your worldview,* Rosling (2006) used a single scatterplot throughout his presentation of *Global trends in health and economics*, and made a complicated topic transparent, intuitive and playful His expert commentary synchronised with graphs and animations, such as moving bubbles and flowing curves, engaged the audience by offering multiple points of visual interplay.

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Figure 3.68 Statistics that reshape your worldview, Rosling, 2006.

Rosling known for his contribution to interactive data visualisations (figure 3.68), highlights the narrative context of information as a red thread through the history of human communication: ‘Today, with all manner of electronic media, the possibilities have grown, but essentially we are still telling stories’ (Rosling, 2006, unpaged). The expanding usage of new media and technology did not change the human ability to communicate abstractly. In contrast, we still explore new ways to transform complex issues into accessible narratives using the technological palette as a tool for storytelling.

In the case of this investigation, I have chosen to focus on visual communication tools for both quantitative and qualitative data presentation since these are, as Schuller (2008, p. 111) present it, ‘…always addressed to a broad target group and mostly concerned with the public and mass communication’. Challenged by this insight, as well as artwork previously summarised in section 3.2 *Emotions, Science, Art and Virtual Worlds*, I have begun to analyse the potential use of infographics and data visualisation as research tools. Where the former, usually handcrafted, represent the illustrations of information such as data or knowledge, and the latter is created by a computer program as a visual representation of data and can be applied to many datasets. Consequently, this chapter explores the aesthetics and objectivity of both of the above, as a search for balance between fact and opinion, in the context of the vulnerability of emotions embodied via movements translated into numbers. The sources of inspiration reveal my motivations via the analysis of art and research as illustrated through the examples below.

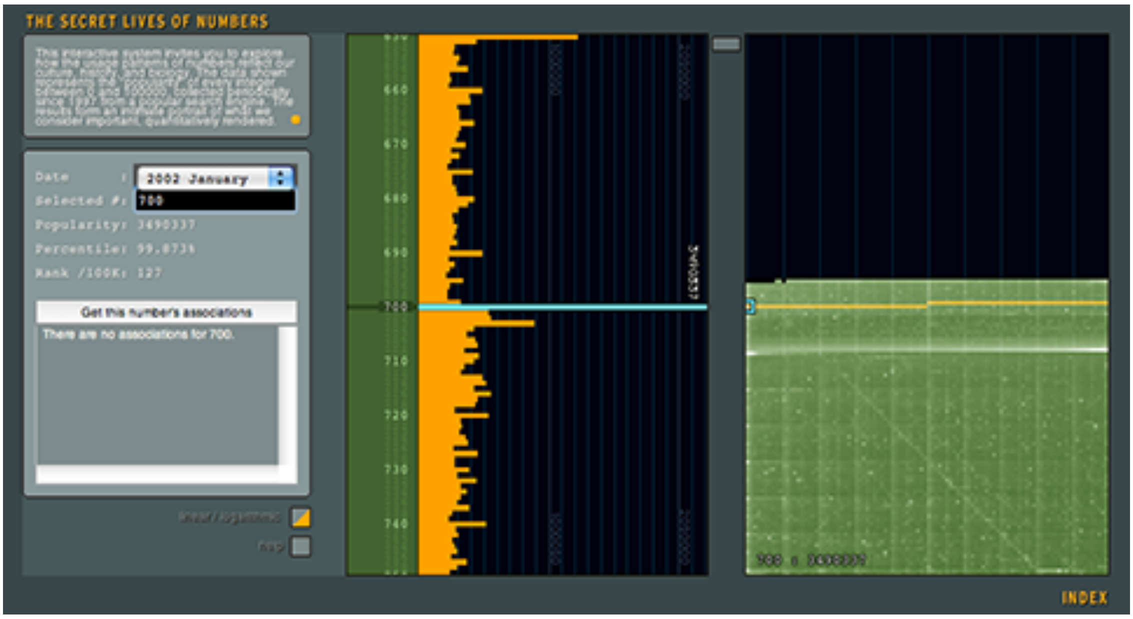

Figure 3.69 The Secret Lives of Numbers, Levin *et al.,* 2002.

The Secret Lives of Numbers (Levin *et al.*, 2002) is an interactive data visualisation that investigates the prominence of numbers on the Internet by an artist, software developer and researcher specialising in computer technology (figure 3.69). Levin's work is devoted to body movement, gesture, audience-interactive performances and installations. During the *Secret Lives of Numbers* project, Levin *et al.* (2002), conducted a comprehensive empirical study over a five-year period, in order to estimate the relative popularity of every integer between zero and one million. This is based on the frequency that each number is present in the databases of popular search engines. The online artwork based on a java applet provides, as he explains '…an extraordinary variety of patterns which reflect our culture, our minds, and our bodies' (Levin *et al.*, 2002). Furthermore, he summarises:

> We surmise that our dataset is a numerical snapshot of the collective consciousness. Herein we return our analyses to the public in the form of an interactive visualisation, whose aim is to provoke awareness of one's own numerical manifestations (Levin *et al.*, 2002, p. 3).

By tradition, we are accustomed to perceiving measurements as superior tools to support an argument. Contingent upon history, numbers associated with the objective evidence of truth are often used to measure human reality. Although, confronting this observation, numbers from a certain point of view are expressions of subjective thoughts and ideas of the people that calculate them, and are generated by choices and priorities of how to calculate them, in which context and how the results are presented. Levin (2002, p. 3) expressed these human choice parameters as; 'a patterned fashion to describe', which is more transparent in the context of his entire statement:

> Humanity's fascination with numbers is ancient and complex. Our present relationship with numbers reveals both a highly developed tool and a highly developed user, working together to measure, create, and predict both ourselves and the world around us. But like every symbiotic couple, the tool we would like to believe is separate from us (and thus objective) is actually an intricate reflection of our thoughts, interests, and capabilities. One intriguing result of this symbiosis is that the numeric system we use to describe patterns, is actually used in a *patterned fashion to describe* (Levin *et al.*, 2002, p. 3).

Analogously, in the dispute on scientific truth in the context of the subjective influences during the measurements of atomic events, the physicist Heisenberg (1958) in *Physics and Philosophy,* concludes that:

> ...since the measuring device has been constructed by the observer, and we have to remember that what we observe is not nature in itself but nature exposed to our method of questioning. Our scientific work in physics consists in asking questions about nature in the language that we possess and trying to get an answer from experiment by the means that are at our disposal (Heisenberg, 1958, unpaged).

Furthermore as an argument to the previous statement Heisenberg (1958, unpaged) refers to Bohr and adds: '...when searching for harmony in life one must never forget that in the drama of existence we are ourselves both players and spectators'.

By referring to these statements my intention is to expose the importance of the perspective from which this research is conducted, highlighting in the process that the 'objective truth' is a type of agreement placed on a bidirectional vector between the presenter and the receiver. In the introduction to section 3.4 *Database, Movement and Data Visualisation*, the question of 'How much influence does the identity have on the identifier?' was raised, where I relate to the simplification that occurs through the extended use of databases as part of human lives and the source of information that describes the individuals. In this context, data visualisation objectivity as a contextualised view is highlighted; the influence that the observer has on what is being observed. Both Levin (2002) and Heisenberg (1958) point out that the presenters and viewers approaches colour the output; a limitation in terms of objectivity as the traditional scientific objective point of view, to which I have added that it requires a formal agreement. From the perspective of arts however, the space between the two points of view, presenters and receivers, is a free space of interpretation that taken into account adds an extended view of correlations. Deleuze (1994, p. 246) identifies it as a 'pre-individual field of the virtual', a human potential based on an intuitive understanding of the core concepts of the whole that both Deleuze and Guattari identify as occurring within the work of art. In contrast to an objective view as defined by science, Guttari (1990, p. 102) defines 'virtual' as an 'impersonal and pre-individual transcendental field'; an ability to exclude 'the self' and a necessary part of human reality. Perhaps, the question of how we perceive the world and how we approach it describes the objectivity of our actions. Merleau-Ponty when clarifying his thesis in the "Primacy of Perception" has formulated this correlation referring to the issue of presence.

> By these words, the "primacy of perception", we mean that the experience of perception is our presence at the moment when things, truths, values are constituted for us; that perception is a nascent logos; that it teaches us, outside all dogmatism, the true conditions of objectivity itself; that it summons us to the tasks of knowledge and action. It is not a question of reducing human knowledge to sensation, but of assisting at the birth of this knowledge, to make it as sensible as the sensible, to recover the consciousness of rationality (Merleau-Ponty, 1964, p. 25).

My intention here is to reflect on the two principal views that I have encountered during this complex study as both an artist and researcher. Mainly, the conflict arises in the background to my phenomenological approach of this study. I use Van Manen's (2003, p. 13) formulation to describe the issue of the quantified emotion…'A poem cannot be reduced to a summary, to a capsule meaning, but rather, to understand a poem is to participate in "how a poem means"'. My point here is complex. Emotion cannot be quantified it should be lived. At the same time, a lack of emotional expressions in digital worlds, not only as representations of game characters' gestures, but as lived expressions depends on sensing devices. These, more or less, still require the simplification of expressions converted to meaningful numbers.

My idealistic perception of the world is both a problem and a driving force and thereby to define my actions, these liminal discussions have provided a reflective tool and describe my process. Along the journey of these philosophical detours, I have chosen another artist's point of view as a comment on 'virtual', 'subjective' and 'objective' by demonstrating at the same time the possibilities of scientific data based on artistic expressions. In this in *Self-Portrait series,* Minjeong (2007), a Seoul-based artist explores the issue of data meaning versus emotional vulnerability, using objective views and scientific methods to expose a subjective experience. The artworks, digital prints, 88.0 x 210.3 cm in dimension (figures 3.70) are outstanding examples of infographics, based on visual techniques such as blueprints and mechanical drawings.

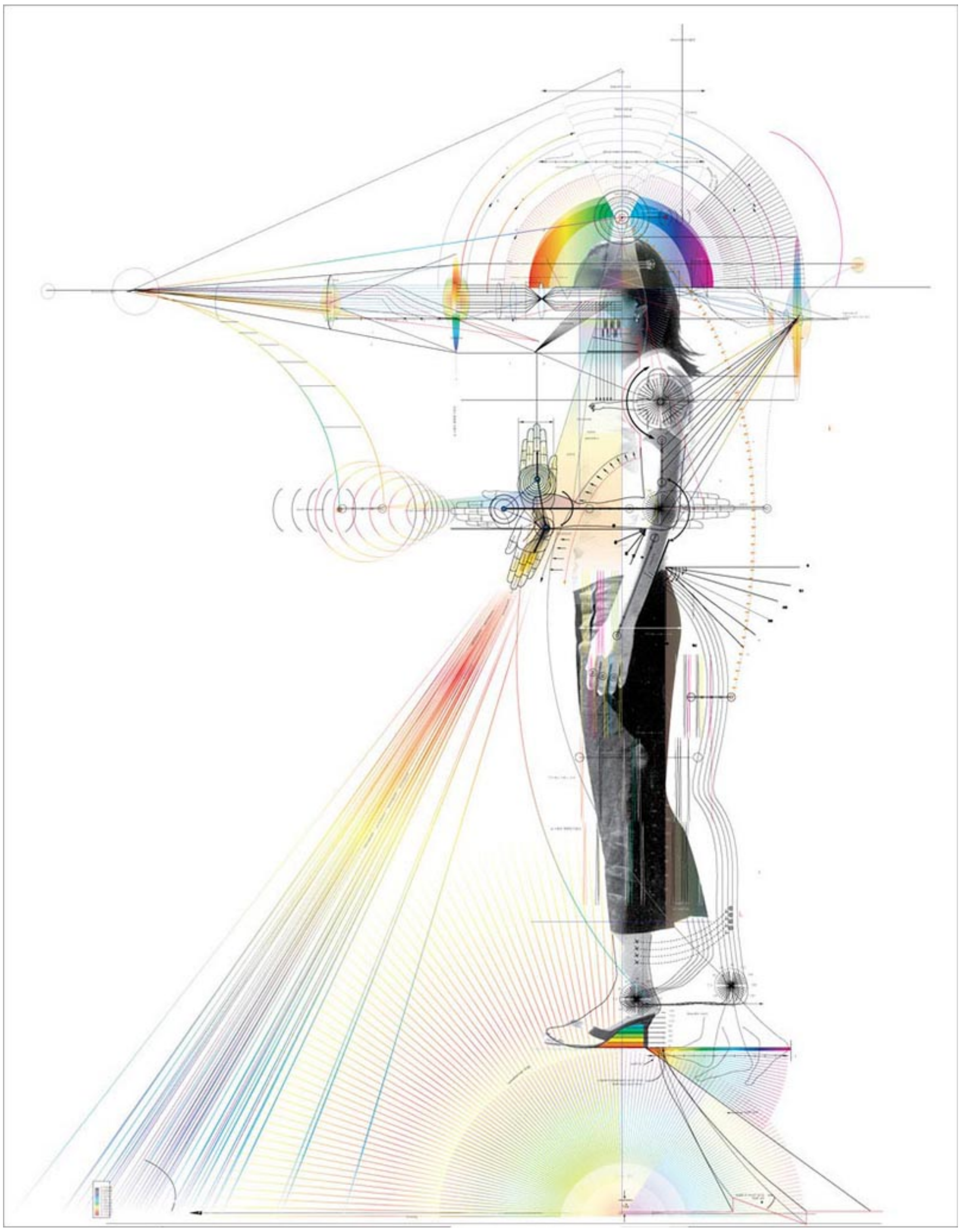

Figure 3.70 Self-Portrait series 1, Minjeong, 2007.

These informative illustrations represent the anatomy of an artist's body combined with her life experiences, memories and feelings as she declares it an exact chart of measurements, yet open to interpretation:

> Creating a portrait of my body in this piece, I employed signs and symbols, like those commonly used in blueprints or mechanical drawings, thus leading viewers to imagine someone whom they haven’t met and possibly to reconstruct a ‘new’ person out of the complicated and yet clearly descriptive anatomy (Minjeong, 2007, unpaged).

These blueprints could be perceived as a method that defines the invisible virtual condition out of which the emotionally and physically experienced reality is explored. With a scrupulous and scientific, yet personal, approach she deconstructs to the smallest detail the data of her life and body in the visual poetics of symbols and lines that form the diagrams, where she is literally transforming her body data into the creation of a visual database of her life. Here, as Minjeong explains, the subjective experience is transformed to visual information as objectified scientific facts.

> I want to discover the true and priceless value out of seemingly insignificant things and share them with others. In other words, I am using the logical and scientific tools to transform something trivial and invisible into something memorable and visible". Furthermore: "it is about the state of being half awake and half dreaming… [and] by using signs and codes, including the anatomy of a brain, reactions within the nervous system, the link between the brain and the eyes, I bring together these two realities" (Minjeong, 2007, unpaged).

Self-Portrait series are based on scientific data representing an artist's emotions and feelings through the symbols and numbers of the body's chemical reactions. These, combined with the visual representations of her body as a memory container, are building a visual database following the trajectory of her life. These examples illustrate a different approach emerging in science and art by using visual technologies mixed with informatics, which I found to be convenient as a way to illustrate emotions.

The next examples show a similar approach to research on emotions from an art and science perspective where visualisation techniques play an important part in the communication of research findings and data acquisition. Both research projects utilised similar methods for data acquisition based on topographical self-reporting methods where participants mark body regions on representative silhouettes of the body. The first example refers to the research of graphic designer O'Brien (2007) *Emotionally}Vague* as previously described in section 3.2.5 *The Resonance of Art*. O'Brien asked participants to draw bodily regions and to choose a number from a numbered colour chart that corresponded to specific emotions (figure 3.71).

Whereas in the second example, based on research from the Human Information Processing Laboratory by Nummenmaa *et al.* (2014), *Bodily maps of emotions*, the researchers asked participants to colour the bodily regions based on which activity they felt increasing or decreasing, while viewing stimuli such as emotional words, stories, movies, or facial expressions (figure 3.72).

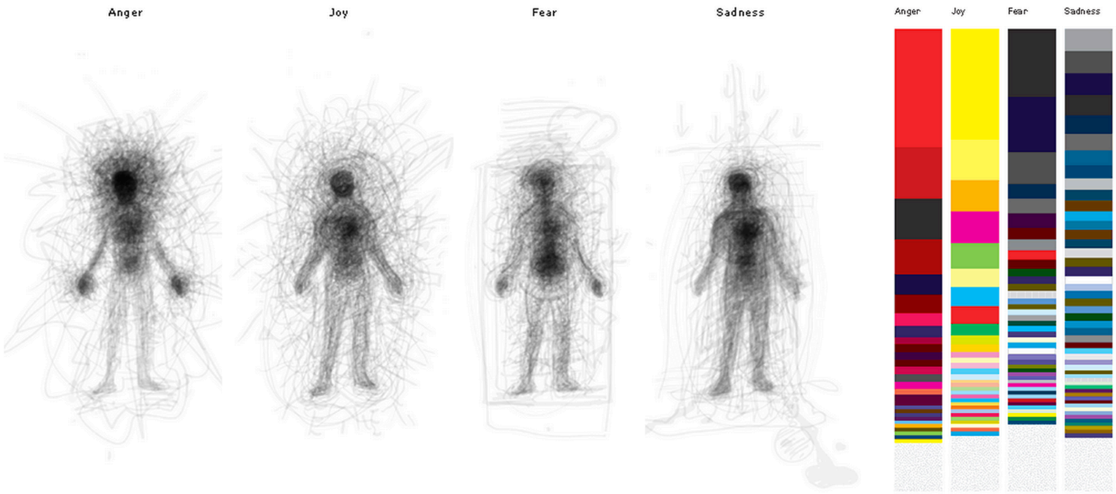

Figure 3.71 How do you feel emotions in your body?, Emotionally}Vague, O'Brien, 2007.

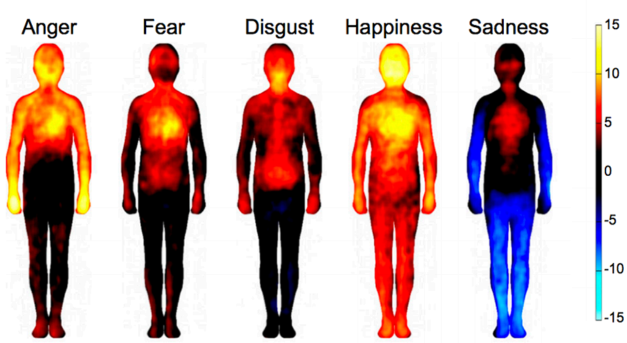

Figure 3.72 Bodily maps of emotions, Nummenmaa *et al*., 2014.

In both cases, the answers were overlaid to create an averaging effect. In O'Brien's, case 250 participants answered questions, whereas in the second case 701 participants responded. The examples showcase a visual biomarker method where only the visualisation is used both to collect data and present the results on emotion based research. The convergence point between scientific and artistic perspectives that charts or diagrams can provide, resulted in charts that became one of the representations of emotions in the PTM database. The scientific and the symbolic value of charts and diagrams as a representation of numbers provided a possible visualisation model of emotions via the analysis of expressive movement. The parameters that describe movement are based on the VideoAnalysis (Jensenius, 2017-2012) tool providing values for movement positions in 2D space and movement quantity according to time. This configuration makes it possible to compare different expressions in order to find patterns and, through this, describe differences and similarities amongst physical expressions of emotions. Furthermore, the patterns contained in the charts bring a different visual dimension that should also be taken into account in the content creation for the database both as an analytic tool and for its aesthetic value.

3.4.5 Conclusions

The primary aim of this part of the contextual research was to investigate the concept of the database as a creative tool where the user is provided assets for reproduction, making and remaking. I was looking at the possibilities the database provides in terms of an open structure, the possibility to create multiple interpretations of the same content, and content that through interface changes, creates multiple of narratives. In this case, the concept of the database is not treated as a permanent data container, but as a tool to create multiple points of view and new data production. At the same time, the database as a container for quantitative and visual data stimulated my interest when I realised the potential of numeric data visualisations as a creative expression, where both scientific and artistic approaches impact each other. However, the contradictions during my inquiry perceived from the phenomenological point of view become a part of my exploration, based on the fact that the objectification of emotion was necessary during the production of artefacts. On the one hand, the process excluded the contextual information of the participants and viewers, and on the other, emotion interpreted as quantifiable objects was required for future adaptations with appropriate sensing devices.

From these philosophical detours, the idea of using data visualisation emerged. Within and between discourses, I was looking for common denominators between the subjective--aesthetic and the objective--informative exploring at the same time the perspective of the detached viewer. The philosophical explorations on 'object' versus 'subject', in terms of visualisation and depicting knowledge, both in the context of history, philosophy and partly based on *Objectivity* (Daston and Galiason, 2007), reflect the contradictions and changes of the definitions. In terms of this research, the division between scientific and artistic representation results in the visualisation of a quantified emotion that contains symbolic value. Looking retrospectively at visualised knowledge shows that methods and approaches result from a series of negotiations grounded in technological opportunities and philosophical influences. The contextual investigation highlighted the possibilities that arise from content interpretation both inside the database structure, and as a content that can be reused and remixed in totally different

contexts when provided as an open public archive. During the investigations, some concerns arose regarding simplifications emerging via the information collected in databases since a large part of human life is informed and controlled by these systems. In the context of the PTM database, the issue of reliability, readability and the communicative values of expressions in the collected data evoked some questions.
As an effect of these concerns, this section was investigating two questions; 'How can embodied emotion be visualised in order to be measurable?' and 'How much influence does the identity have on the identifier?'

The questions are posed from a twofold perspective; on one side is the interrelation between a socio-cultural conditioned view on bodily expressed emotions as a communicative tool in data acquisition and visualisation. On the other, the absence/presence of these unconscious relationships in a scientifically preconditioned data evaluation, as a part of the visualisation process. Besides the historical context of depicting scientific findings, these issues were investigated through the body of work of contemporary artists in the fields of art, performance art and music composition. The focus on the arts was intentional since investigations on the human body and movement in the context of the database, and the underlying technology, are discussed in these fields from multiple perspectives. This conclusion originates from the investigation described in the previous section 3.3 *Movements, Body, Art and Technology*.

My exploration from the phenomenological point of view, of the issue of the factual representations of emotion that can be measured and quantified, brought me to the philosophical detours expressed in the second and rhetorical question; 'How much influence does the identity have on the identifier?'
The issue of numbers as the objective evidence of the 'truth' that has been a controversial and much disputed subject within both fields of science and art, continued to be examined through this research. Levin *et al.* (2002) and Heisenberg (1958) argue that both the viewer's approach and the one that collects the data, influences the output. Looking from the analytical point of view, the properties of emotion collected in the database are representations of both the participants' interpretations of emotion and my approach to how these are visualised. The way we interpret expressed emotion will inevitably be affected by the senders and receivers unconscious subjective relation to emotional expression, as deeply rooted and conditioned by culture, history and personal experiences.

However, looking from the associated phenomenological perspective, the inclusion of the personal, subjective experience makes the interpretation visible.
The emotions contained in the database are interpretations based on the understanding of both the receivers and the creators - i.e. the ones who embodied the emotive expressions. Extending this insight to future developments, the participants who will use the data contained in the database, by mixing and remixing the visual material, will provide new data grounded in their own interpretations. As a result, a more holistic view of emotions will begin to crystallise.

The possibilities that occur via the open database, as in the example from *The Visible Human Project* (2003) described in section 3.4.3; *From Data to Knowledge, Database as Research Tool*, provides multiple variations and perspectives on the expressiveness of human emotions. Only by collecting these interpretations can we come closer to answering the question: 'What is emotion?'
A specific insight has evolved from this notion, which also justifies the idea of an extensive database of emotive movement and gesture, at the same time answering the question: 'How to explain emotion in the context of corporeal movement in order for it to be measurable?'
During my working process, I extended the database content with different representations of emotive whole-body movements such as: silhouettes in motion, timeline chronophotographies and quantitative movement measurements represented as charts and plots that indicate expressiveness and the communicative qualities of gestures.

To explain emotion we need multiple representations of each emotion and a different form of data representation. These two combinations provide a sufficient amount of information in order to make associations between the different representations making them measurable and quantifiable in the context of many subjective experiences. To understand the phenomenon of emotive expressions, we should not just see the behaviour but also interact with it, transforming it into various expressions and representations of multiple experiences. Consequently, for the future expansion of the database, I anticipate that any additional input of data will be provided by movement sensing devices; a conclusion which determines my priorities for future research, but beyond the scope of this doctoral study.

3.5 Discussion

> *I see the world's pendulum swinging back away from technology to something more human, more authentic. (Maeda, 2008, p. unpaged*)

The contextual research running in parallel with the practice-based investigation, aimed to contextualise my practise-based inquiry in the search for facts, arguments and inspiration. Additionally, my intention was to highlight the adaptability of methods used in performance art to the field of game graphics and game design. This would mainly be achieved by exemplifying cases in which the human body converges with technology in a way that could be used as inspiration. Nevertheless, my research focus fell within the general terms: emotional expressiveness, empathy, embodiment, presence, and data representation.

Beside the traditional voice of academic discourse, I have in some parts used a first person's voice reflecting on the issues discussed, from my level of experience. My intention with this approach was to document the multiplicities of perspectives involved. This tactic resides in the phenomenological approach in which I choose to confront the subjective and objective methods of inquiry as a part of the documentation process. Additionally, since I searched for arguments from a particular point of view, and from a predesigned position, these needed to be clarified in every iteration of the research process. This enabled documentation of the different layers of perspectives in which human thought is involved, and in which every object of inquiry is investigated on many levels of perception.

Once, when Grotowski (1968) was asked about the association between the name *Theatre Laboratory* and the scientific research the name implied, he explained the subject as a metaphor, which illustrates to some extent my working process during this contextual research:

> The word research implies that we approach our profession rather like the mediaeval wood carver who sought to recreate in his block of wood a form, which already existed. We do not work in the same way as the artist or the scientist, but rather as the shoemaker looking for the right spot on the shoe in which to hammer the nail. (Grotowski, 1968, p. 27)

Some contradictions in my working process exist, reflecting two aspects of the research issues; the cognitive and the embodied process. In reference to the latter, I would rather describe this as reflections based on, and pointing at essentially, the non-verbal. Therefore, since experience can be resistant to description, I have chosen to provide my own thoughts and reflections on the issue. During the practice-based part of the research, I experimented with scientific methods as artistic tools, yet the work process became more of one associated with a librarian rather than an artist. This provided philosophical reflections mainly connected to interpretation and the structures of information founded on a conceptual knowledge organization in computer based representations, i.e. ontology.

When summarising the findings based on contextual research it is important to highlight that these have affected the methods chosen during the design of the PTM database. Investigations described in section 3.2 *Emotions, Science, Art and Virtual Worlds*, have revealed that in recent years, philosophy, psychology, and neuroscience have contributed new observations and insights into the brain and bodily processes involved in different states of emotions and their relationships to our perceptions and actions. These observations support the conclusion that bodily changes and the experience of the body are inextricable aspects of emotions, and of most other aspects of the mind. Emotive whole-body movements and gestures are highly connected to social communication skills developed during a long-term evolutionary process and highly important as a communication tool in all socio-cultural aspects. Furthermore, emotions are reversible i.e. facial expressions; body movements, postures and gestures can provoke emotions. Findings from the cross cultural studies of Altarriba *et al.* (2003) and research on human behaviour, based on several studies on facial recognition, conclude that there exists some degree of universality of emotional expressions. This universality among six basic emotions; happiness, surprise, fear, sadness, anger and disgust, enhances the theory of emotions advocated by Plutchik (1984) and provided a solid grounding for the database construction.

Based on the reflections gained during the contextual research it became apparent that as technology advances, reality and virtuality merge together, changing our perceptual experience. As cultural boundaries cross new technology and new media developments, spectators can experience film in places other than cinema, performing arts elsewhere other than in theatres and concert halls, and art is explored outside traditional exhibition spaces. A clear trend seen in these changes is that there has been a shift in the viewer's position. We regard as second nature the participatory experiences the variety of digital information and social networks provide, however, we are mentally absorbed in a computer environment. Yet, the interest in this novelty is receeding, as Maeda (2008, unpaged) has expressed, ‘The world's pendulum swinging back away from technology to something more human, more authentic’. Controversially, technological advancement opens the doors for a paradigm shift in the way we look at and experience, the human body, confronting us with its vulnerability.

The performer artist's approach to technical advances is often radically different from the engineer/computer scientist or programmer since the technology is used from the body's subjective perspective. The physical body "sees" the world’s in terms of affordances and communicative aspects, in which the technology is a tool to amplify the kinaesthetic actions and perceptions. In the course of previous reflections, the knowledge transition from performance art to game education and research could provide a new type of challenge for the game that engages both the cognitive and physical actions of the player. The kinaesthetic game requires player’s physical and cognitive input to overcome the challenge of the game. However, knowledge exchange across those fields has been comparatively limited. Therefore, future technological developments ideally require the cooperation of all representations of knowledge and in particular the development of embodied games, which require an interdisciplinary approach at the educational and research level.

As the technical development creates new dependencies and possibilities the need for a common meeting point to provide new methods, new terminology, and understanding based on a new approach is stressed (Diamond, 2002; Forsythe, 2009; Norman *et al.*, 2010; Vesna, 2000). The complexity between knowledge and imagination reviewed in section 3.4.2 *Bridging Boundaries: body>data>body*, is an attempt to understand the artist's view debated in the context of how physical data could influence the discussion on the future development of technology and new media tools.

The overview of the art-technology field provided the insight that investigations of kinaesthetic perception have been largely led by artists from the performative and visual arts, pushing the boundaries by adapting technology to the physical corporeal movement. We can observe a growing field of dance-technology art, independent communities of artist-technologists, computer geeks and open source communities that

contribute and push forward body-centred technologies with new ideas.
As the interest in body-centred knowledge has advanced, the situation in games development has changed rapidly, where the development of movement sensing is mainly taking place in the computer labs and research facilities of leading games development companies such as Microsoft and Sony. Thanks to the introduction of movement-sensing hardware and software such as Wii and Kinect into the public marketplace, physical games have reached a broader audience. However, in the convergence process between the real and the digital, much work remains in order to include whole body movement and gesture as driving forces in narrative content and game mechanics. The innovative research emanating from dance-technology art, and the independent community of artist-technologists has not yet reached the game education and research arenas on any significant scale.

Within the scope of this research, a question arises; how physical data influences virtual data and how we can visualise such complex patterns? This question has been elaborated on during the practice-based research and revealed via the working process described in Chapter 4 *Art as Vehicle, Research in Practice*. At the same time, section 3.4 *Database, Movement and Data Visualisation* is an attempt to confront this question through the investigation of the database concept both as a data container and as an artist's tool, as well as through the investigation of different forms of data visualisation techniques. In this context, my concerns regard the possible simplification that may occur in transitions between the real and the quantifiable, as well as the objectivity of numbers translated to charts. In this respect, my own philosophical detours stressed an investigation of methods used for the visualisation of scientific findings and contextual research that preceded the historical background of epistemic inquiry that resides in philosophical ideas. Sections 3.4.3 *From Data to Knowledge, Database as a Research Tool* and 3.4.4 *Visualising Data*, are reviews which follow both facts and artistic detours.

The idea of emotions as numbers in the digital world offers a different experience of disembodied presence. When analysing various bodies of artwork from the perspective of the PTM, it became apparent that several related areas required deeper investigation for future research on comparative databases in connection to motion sensing technology. Nevertheless, I found several examples of artworks that elaborate on the issue of physical presence in digital environments that in this study becomes a source of inspiration in terms of movement visualisation and is reflected in the final output of the research.

Section 3.4 *Database, Movement and Data Visualisation* illustrates the contextual research on issues such as, the database as an artistic tool and quantitative data visual representation methods and artworks. This part was significant for both movement pattern analysis and the statistical data generated from the video material evaluation; a visual material enveloped in the database. During the research, the issue of numbers as the objective evidence of the 'truth' has been my concern. From visual data collection to the transformation of embodied expressions to numbers and later to charts and diagrams, the issue of validity equally continues to be examined throughout this research, in the context of the PTM database. The issue of reliability of the data collected, data collection methods and visualisation as well as the process of database design, was an exploration of models of inquiry on which our perception of the contemporary world is built.

In order to grasp the embodied representation of emotion, we need different representations for different types of data. In this context, the famous phrase "The medium is the message" coined by McLuhan (1964, p. 23) illustrates the idea behind different emotive movement representations in the PTM database. Consequently, the result of these findings are embodied in the PTM database creation.

In conclusion, I found it suitable to summarise this section with Paul Klee's (1961) "Creative Credo": 'Art does not reproduce the visible; rather, it makes visible' (Klee, 1961 p. 76), which he further explains in the same chapter:

> Formerly we used to represent things visible on earth, things we either liked to look at or would have liked to see. Today we reveal the reality that is behind visible things, thus expressing the belief that the visible world is merely an isolated case in relation to the universe and that there are many more other, latent realities (Klee, 1961, p. 76).

In the course of this research, the idea of information representation is highlighted, where data visualisation plays an important role. On the one hand, visualisations are an efficient medium that communicates a message, on the other, as a visual image forms, the relationship between the different parameters of movement data are possible to highlight but not categorise as hierarchical structures.

4 Art as Vehicle, Research in Practice

4.1 Introduction

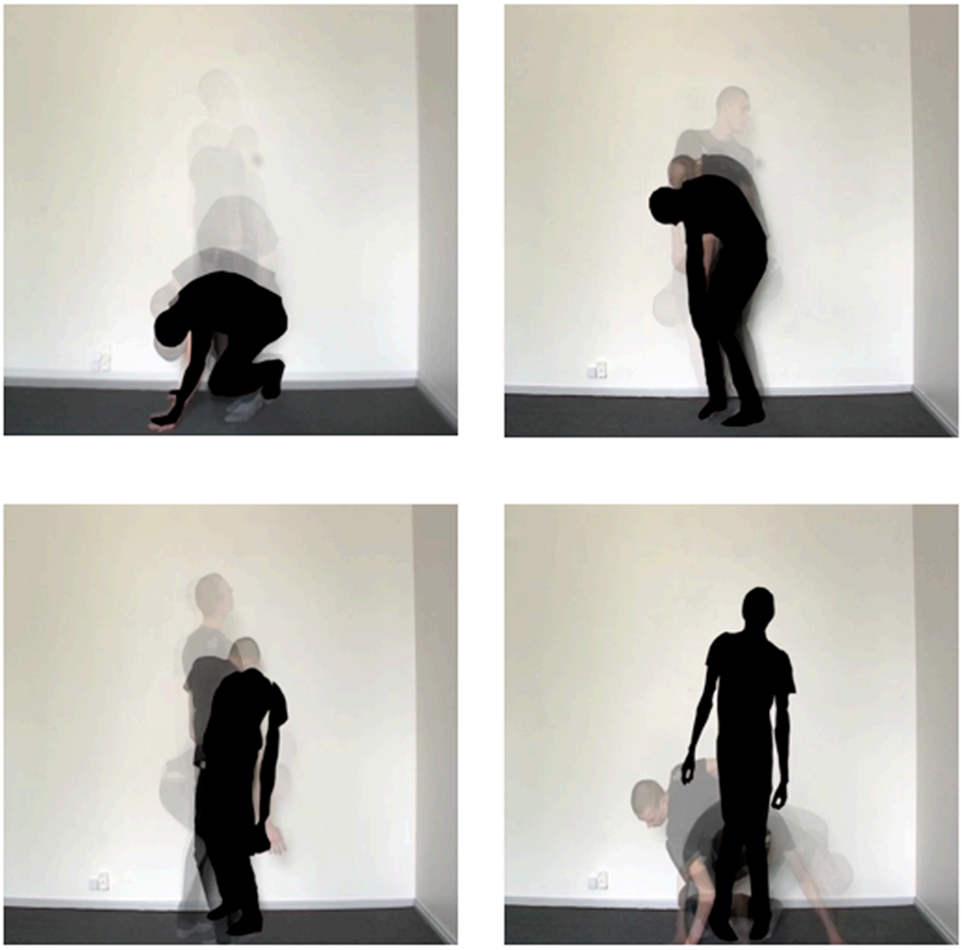

Figure 4.1 Gestalting emotion; explorations during Tallinn workshop, Hrynczenko, 2010.

In Swedish and German *gestalt* means literally, *shape, form, figure, configuration* or *appearance*. In English, it refers to a concept of 'wholeness': 'something such as a structure or experience which, when considered as a whole, has qualities that are more than the total of all its parts' (Cambridge Advanced Learner's Dictionary, undated.). Scandinavians and Germans apply this word in a certain context as a verb: to "gestalt" as a description of a creative process from concept through the realisation process, to the final artwork. I found the semiotic interesting since it appeals to the way I work as an artist, performer and designer.

The word "gestalt" gives the process of creating a more visible layer and the possibility to apply and combine different research methodologies to the exploratory process while maintaining the same value as the final artefact. However, the methods that I use produce aesthetics based on the individual, subjective perceptions, as opposed to purely cognitive processes and scientific methods. In connection to the project, the word gestalt gives shape and form to the moving body according to physical and emotional space (figure 4.1), which is crucial in the process of this research.

Consequently, the following questions arise: How do emotions form our gestalt? How do we gestalt the emotions? Moreover, the question, what gestalt could a specific emotion take? These queries all contribute to the final question:

How could emotions expressed via whole-body movements be visually documented as a reference framework to stimulate the use and studies of expressive gesture in digital environments?

The research was driven by the previously defined idea, a need to form an output applicable to a wider context beyond the written text, and against the background of a highly subjective and physical reaction of the body in the digital environment, as in front of the computer screen or "on the floor" working with it in the *Mocap capture studio*. When observing bodies of others in similar situations, some concerns relating to the human body have arisen. Namely, that we are not present in the body when interacting with technology, but become an extension of it in terms of kinaesthesis (i.e. have a sense of bodily position, weight, muscle tension, and freedom of movement). Likewise, in terms of technical advancements such as: new social interaction platforms, information structures and communication, I am concerned about the ongoing process of simplification of human identity. This is exemplified through the reduction of human needs and the identification with technologies driven by economic forces (Becker, 2003) based on the rationalisation of humans to a statistical number related to what they buy, where they live, where they eat, and more recently, with whom they communicate and why (Snowden, 2013). Guattari defines this post-industrial global symptom as integrated world capitalism (IWC) and asks:

> Why have the immense processual potentials brought forth by the revolutions in information processing, telematics, robotics, office automation, biotechnology and so on, so far only led to a monstrous reinforcement of earlier systems of alienation, an oppressive mass-media culture and an infantilising politics of consensus? (Guattari via Genosko, 2001, p. 500).

Degrees of physical alienation in the digital environment is one of my main concerns and the background for the choice of the thesis subject for this doctoral study, therefore the investigation is focused on tools and methods for explorations of bodily expressed emotions; i.e. human expressive movement and gesture. The idea was to create a layered view, where emotive expressions could be celebrated from different perspectives.

The sections outlined below briefly describe the journey taken during the research that investigates expressive movement and gesture in the context of transition from the real to the digital. The main intention, a database of expressive gestures and the Periodic Table of Movements (PTM) should not be perceived as a final answer to previously posed research questions but rather as a tool to drive the process of questioning, an environment for research.

Section 4.2 *Pedagogical Toolset* describes tools used during the DAMA workshops (documented in Appendix P) that created a platform for the movement documentation process described in section 4.3 *Emotions/Movement Documentation Process.* This section provides an overview of visual data collection, focussing on the practical issues and workflow.

The working process for data visualisation is described in section 4.4 *Movement Visualisations Process and Data Aesthetics.* The design process, prototyping and final construction of the database are presented in section 4.5 *PTM: Web Based Database.* The main chapter, Chapter 4 Art *as Vehicle, Research in Practice* ends with a discussion that summarises all the findings from the perspective of this doctoral study. Research in practice is based on the data collection of emotive expressions visualised as silhouettes, the classification of movements according to emotions in a database system, and the visualisation of characteristics for each emotion both as charts and as a chronophotographical time series.

4.2 Pedagogical Toolset

> *Creativity involves breaking out of established patterns in order to look at things in a different way (De Bono, 1990, p. 1)*

The pedagogical toolset was developed as the result of the insights gained during pedagogical studies (2009–2010), previous experiments and research, as well as my experience as a teacher both during the DAMA workshops and at the Depatment of Game Design at Gotland University, Sweden, teaching animation for games. The toolset, completed during this doctoral study, focuses on movement in digital environments, aiming to provide simple tools for students in games and dance education to experiment with human movement and gesture during the workshops. In the context of this doctoral research, the toolset was used as a part of practice-based exercises where students learned via cross-disciplinary projects during the DAMA workshops, described in Appendix H and Appendix P.

The issue and the background of pedagogical tools such as interactive installations and *Framework For Action Points* are widely described and discussed in Appendix A *Shadow Dance: installation and discussion on proposed solutions for embodied games through cross-disciplinary workshops within an educational context*, presented at the DRHA: Digital Resources for the Humanities and Arts conference, Brunel University (2010). The toolset envelops both pedagogical methods as well as software/ hardware based applications that were used during the DAMA workshops. The intention of this approach was to incorporate physical movement into game education and to include the new technology in dance/ performance classes.

4.2.1 Shadow Dance

The intention of the application *Shadow Dance* (Hrynczenko, 2009a) is to change the perspective of the physical body from ‘object’ to one of ‘subject’ in terms of bodily experience. During the industrial revolution, the human body was presumed to adapt as a component of the industrial process (Lieberman, 2013; Rauning, 2005). This perception continued in postmodern cultures during the development of digital environments, along with human-computer interaction models and automatically prepared the foundation for today's gaming culture. ‘Becoming a piece with something else means something fundamentally different from extending oneself, projecting oneself . . .' (Deleuze and Guattari, 1972, p. 465). Advances in technical developments should allow us to take into account a more holistic human approach, and therefore it is important to discuss how to reduce these knowledge gaps (Hrynczenko *et al.*, 2010).

The Gurdjieff movements, German expressionist dance, and Butoh ideas are confronting these spiritual and philosophical underpinnings providing the conceptual base for the development of the *Shadow Dance* application.

Shadow Dance (Hrynczenko, 2009a) was developed using Pure Data (Puckette, 1996-2015) as a result of previous research studies from 2008–2009 in the "pre-Kinect" era. The application is a responsive system based on webcam input, which allows movement information to be displayed on a multi-layered projection making it possible to follow movement trace histories of a performer in real-time. Participants use their bodies as the interface to influence the visual information projected as shadow and movement registrations received from the camera. Stimulating bodily consciousness, new visual effects are produced via participants' movements that, drawn on the screen, build patterns that extend the body parts radially, symmetrical from their joints (figures 4.2, 4.3, 4.5).

Pattern size depends on gestural expression and intensity, illustrated here in a schematic action flowchart (figure 4.5). The possibility to extend the virtual body opens a kinaesthetic consciousness for the participants. Depending on the movement intensity of participants, the output is stored on a website as key movement frames using a database built on the Extensible Markup Language *(XML)* and Hypertext Preprocessor (*PHP*) scripting language. Movement representations are replayed for the participants as visual collections inspired by the chronophotographic works of Muybridge (1878, 1887a, 1887b) and Marey (1870). Video documentation from the installation *Shadow Dance* (Hryczenko, 2009a) held at the Visual Research Centre, Dundee Contemporary Arts (DCA), Dundee, U.K. is available on the DVD/Video 1.

Shadow Dance (Hrynczenko, 2009a) invited participants to explore body movement in two ways. Firstly, to explore their own body in motion in a playful way as an expressive movement, and secondly through experimentation participants are invited to connect their physical movement with the visual experience thereby opening the possibility for the exploration and analysis of their visual movement trace via a virtual mirror.


Figure 4.2 Shadow Dance; Movement patterns, Slow movement, Hrynczenko, 2009a.


Figure 4.3 Shadow Dance; Movement patterns, Fast movement, Hrynczenko, 2009a.

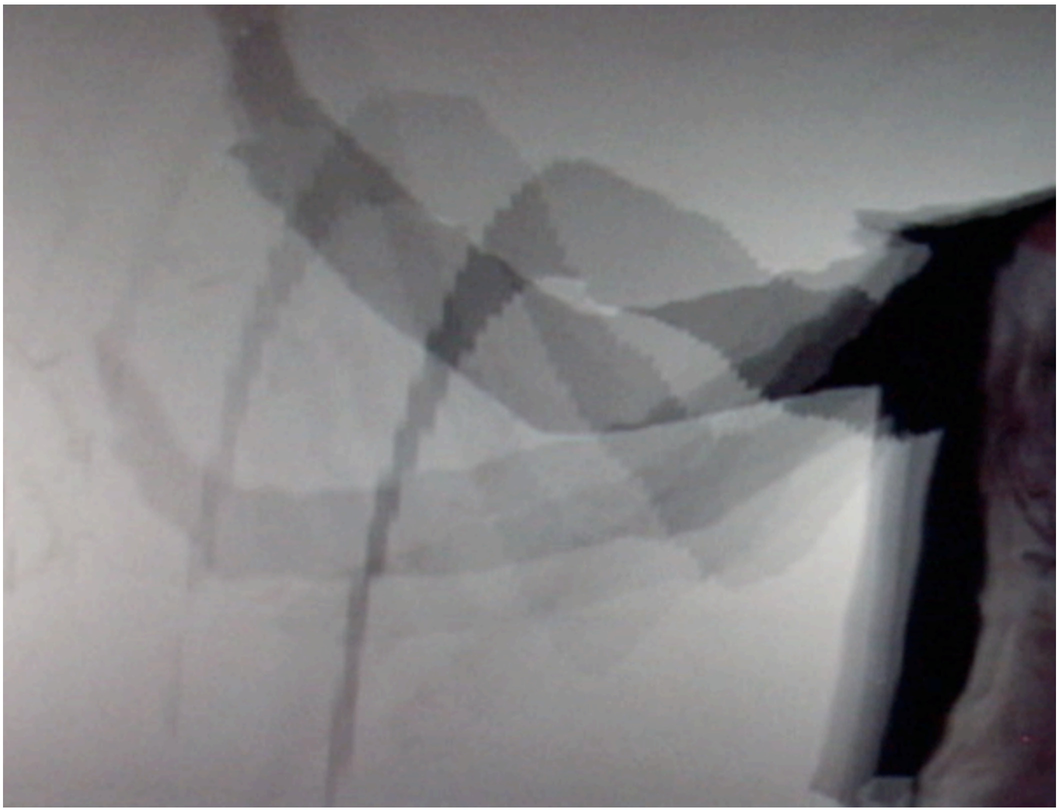

Figure 4.4 Shadow Dance; Movement patterns, Very fast movement, Hrynczenko, 2009a.

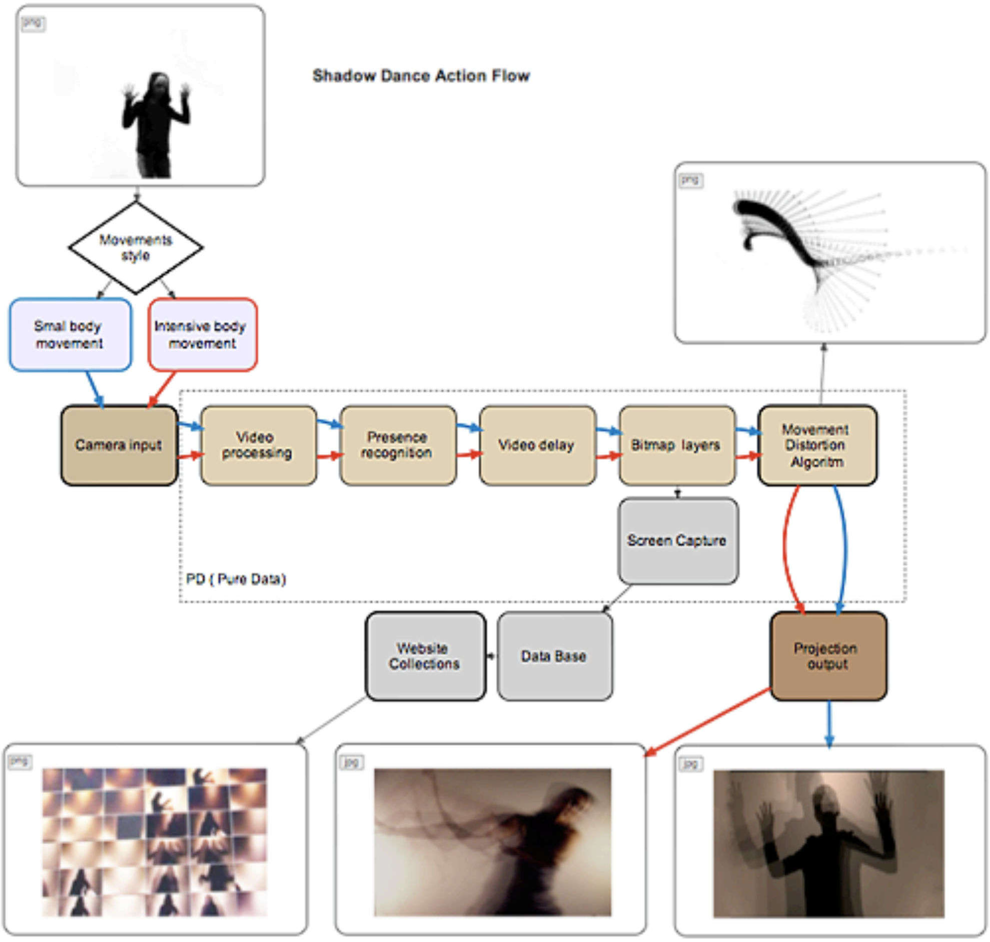

Figure 4.5 Shadow Dance; Flowchart, Hrynczenko, 2009a.

Exercises with *Shadow Dance* (Hrynczenko, 2009a) develops a deeper understanding of the physical process of movement, the individual movements' relation to anatomy, the mechanics of specific joints of the human body and personal kinaesthetic perception. Secondly, the movements documented and stored on the website can be used as examples for further movement analyses, and as sketches when consciously reflected corporeal movement could be useful in character development in games. Additionally, these could also be used as an exercise for preproduction shooting in a *Mocap capture studio* (Hrynczenko *et al.,* 2010).

The main concept of *Shadow Dance* (Hrynczenko, 2009a) is to play with whole body movement and gestures where playfulness is the engine to the creative process through the movement. Huizinga (1955, p. 1) situates play as a source of all creativity 'Play is older than culture, and all culture is a form of play.' In this context, *Shadow Dance* (Hrynczenko, 2009a) extends the idea of play to a purely embodied experience in the search for different content for games.

4.2.2 Flowchart of Human Movement Classes

The *Flowchart of Human Movement Classes* (Appendix I) serves in general, as an analytic tool that aims to define behavioural aspects of movement. It is a cartography of movement and a pedagogical tool aimed at understanding movements in the context of phenomenology defined by Van Manen (1990). Primarily, the table was designed during the first iteration of the research as part of the analyses of movement for the PTM database and was based on my previous choreography and performance exercises and workshops. However, I found it useful during the DAMA workshops as a foundation for common semiotics for physical movement descriptions, that are part of the *Framework of Action Points* described in the next section.

In the *Flowchart of Human Movement Classes,* human movements are divided into six different classes, which use the phenomenological point of view as a basis. The x-axis of the table contains the categories of corporeality, relationality, time and space. The y-axis represents movement categories that are explained as follows:

Reactive: movements that express a mood or feeling provoked by the state of the mind, which consequently can occur in relation to existential circumstances, or be provoked by another human, animal, or object.

Generic: Movements that are a reaction to circumstances that could be conscious or unconscious, mainly supporting existential needs on a basic level such as reaching out, walking or protective movements, all learned from the first days of our existence.

Habitual: Movements to move another human, animal or an object (examples include the use of tools during activities such as eating, drinking and working).

Communicative: Movements that consist of symbolic signs instead of words. Movement is the oldest form of language that evolved before or perhaps simultaneously with speech, for example waving as a greeting.

Lingua-Supportive: Movements supporting a verbal communication spontaneously generated by a person telling a story, speaking in public, or holding a conversation.

Contemplative: Movements with the purpose of changing the performer's state of mind, sometimes to provoke a sensation of spiritual harmony.

It is important to mention that when translating these observations into the digital environment, the movement could be described using parameters related to Cartesian Space, the volume, and the time of the performed movement using parameters such as movement singularity or repetitiveness.

The *Flowchart of Human Movement Classes* (Appendix I) is a general approach following the bodily movement based on brain development from the newborn infant to the fully developed adult. This table is not complete, and further development is needed in terms of movement context and the circumstances that provoke specific expressions. Research in this area is ongoing in the fields of neuroscience, sports, performance art, robotics, music composition, and interface design and should be used for comparison. In conclusion, further research on the *Flowchart of Human Movement Classes* is needed to present other parameters that affect the origin of specific movement characteristics. .

4.2.3 Framework of Action Points

Based on experience from the cross-disciplinary workshops with DAMA, this practical, project-based knowledge exchange between students has given rise to many innovative solutions, assembling core knowledge from their domain-specific skills (Knuutila, 2007). Originally, the *Framework of Action Points* developed as a result of the cross-disciplinary DAMA workshops, encompassing areas such as physical gaming, media arts, dance, urban planning, and game design. The framework is defined as an effect of this research using previously defined movement classes as an analytic tool. Based on pedagogical methods, the purpose is to provide students with a common grounding in movement based on self-notion and game design. This *Framework of Action Points* constituted:

1) Physical exercises, such as movement sequences: goal-directed functional, expressive-emotional, parallel mirroring, abstract improvisations, rhythmical introvert, rhythmical extrovert, and communicative gestures in pairs.

2) Group trust exercises such as caring and touching, falling, and catching.

3) Common semiotics for physical movement descriptions verbalised during the performed movement.
4) Analyses of the visual movement trace via a virtual mirror, *Shadow Dance*.
5) Simple character based live games using floor and urban space.
6) Dance with cameras (seeing body movement through the camera in real-time).
7) Camera as a first person shooter (seeing the space through the camera in real-time).
8) Dancing and running when blindfolded.
9) *Mocap capture studio* exercises, crossing 3D space.
10) Game development theory.
11) Movement sensors.
12) *Shadow Dance*, visually extended movement, body movement and gesture explorations.
13) Acting eight basic emotions in front of the camera.

4.2.4 Tool for Video Movement Analyses, *16 Frames*

The tool *16 Frames* (Hrynczenko, 2010b) is based on Flash, a timeline-based animation editing and programming software application with the ability for online publication using Flash Player. Figure 4.6 illustrates the tool and its interface design. The first prototype was *In Motion (*Hrynczenko, 2008), an interactive dance film collection based on ten video frames built in Macromedia Director in 2000, and later recomposed during the Mediamatic/Cinedans film festival workshop 2008 using the Korsakow System (Thalhofer, 2007), public domain software for interactive film making.

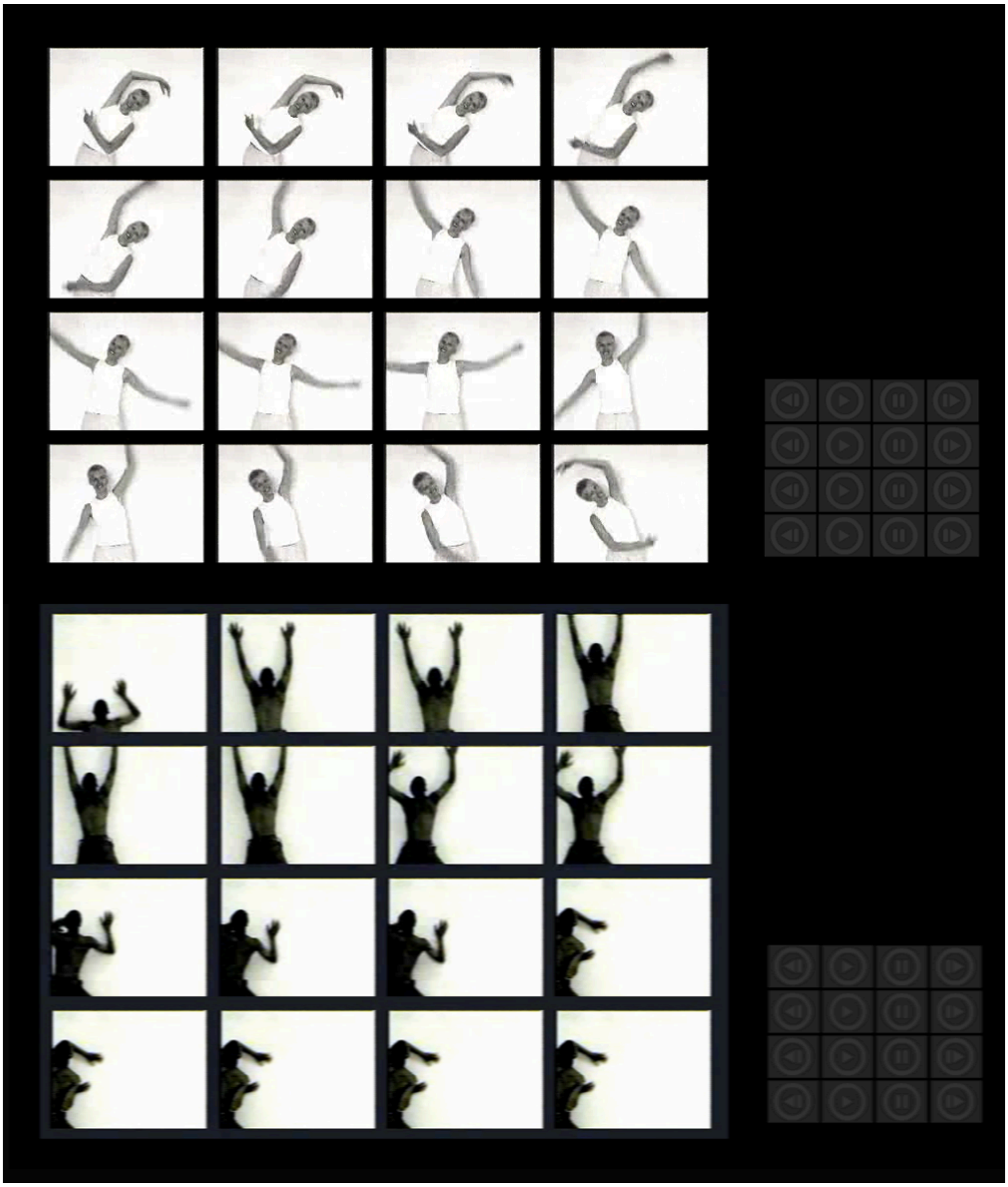

Figure 4.6 16 Frames, Hrynczenko, 2010b.

The main aim of *16 Frames* (Hrynczenko, 2010b) is to visualise sequential movement over time. The idea was inspired by early experiments by Muybridge (1830–1904) and Marey (1830–1904) in chronophotography, discussed in section 3.3.2 *Body in Motion in Timeline and Space.*

In this context it is important to highlight Marey's invention of the chronophotographic gun (1882) that could take twelve consecutive frames per second and record them on the same picture, as well as his cooperation with the inventor of the twelve-lens camera, Albert Londe (figure 4.7).

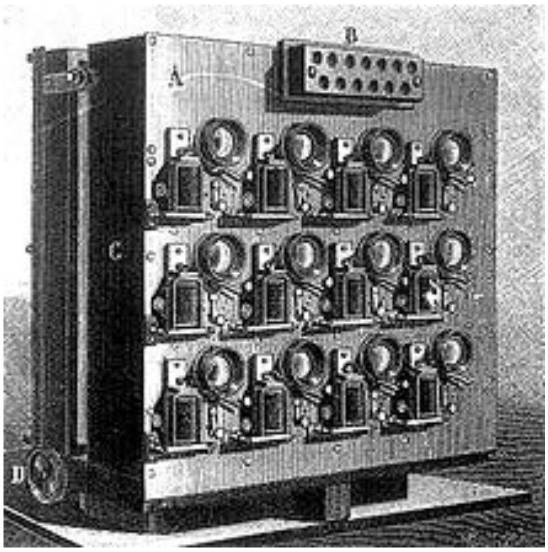

Figure 4.7 Twelve lens camera, Marey and Londe, 1893.

In this context it is important to highlight Marey's invention of the chronophotographic gun (1882) that could take twelve consecutive frames per second and record them on the same picture, as well as his cooperation with the inventor of the twelve-lens camera, Albert Londe (figure 4.7). The idea of consecutive frames in the same picture is also used in the visualisations of the timeline for each video in the PTM database. The *16 Frames* (Hrynczenko, 2010b) is a refined version, which unlike the previous experiments has an option to freeze sixteen separate sequences of video simultaneously.

The purpose of this option is to support movement analysis and is thus a possible feature for the future extension of the PTM database, which would allow different videos to be loaded simultaneously for comparison. However, during the workshops it was used as an explanatory tool for movement sequences.

4.2.5 Summary

Shadow Dance (Hrynczenko, 2009a) was used during the DAMA workshops to allow students to develop a deeper understanding of the bodys' movements physical processes, and the relationship of the movement to the anatomy and mechanics of specific joints of the human body and personal kinaesthetic perception. *Shadow Dance* was used during warming up exercises before video shooting providing participants with a tool that helped them to attune to their physical body in a playful way. In this way the application became a meaningful part of the documentation process.

The *Flowchart of Human Movement Classes* (Appendix I) was created in the context of heuristic guides grounded in phenomenology (Van Manen, 1990, p. 10) reflecting on the human experiences of lived space (spatiality), lived body (corporeality), lived time (temporality), and lived human relation (relationality or communality). The table was a helpful tool in terms of movement analyses both during the workshops by providing a framework of action points, as well as during analyses of the video material providing a framework for the final conclusions in terms of the relationships among emotive expressions. *The Framework of Action Points* is a list of methods that were used in cross-disciplinary workshops with students with the aim of extending knowledge in both dance/performance and media art. In relation to this research these methods were used as a grounding for the workshops by providing a platform for documentation work.

The tool *16 frames* (Hrynczenko, 2010b) is used for movement analyses as well as functioning as a tool for movement documentation when stored on its associated website. In the context of the PTM the database was used during the first iteration of movement analyses in order to compare expressive movements between different emotions. However, the method was abandoned during next iteration, based on the time consuming manual transfer of 76 video files. The *16 frames* tool was designed for a small number of files where just four videos could be compared at the same time. Instead another method was used based on a timeline series using superimposed video frames as described in section 4.4.5 *Movement and Posture as Chronophotographic Charts.*

4.3 Emotions/Movement Documentation Process

This section describes the process of movement documentation during three different iterations that took place in Tallinn and Visby during the DAMA workshops (Appendix P) and in Stockholm in a specially built studio. The content of this section provides the overall documentation and descriptions of the preproduction, production and postproduction processes undertaken during the first two years of the research.
The expressive movement documentation covers the three different phases of the research process, the development of ideas, reflections and solutions, while encompassing descriptions of the practical use of the pedagogical toolset previously described in section 4.2 *Pedagogical Toolset* and the performative techniques discussed in section 3.3 *Movement, Body, Art and Technology*.

4.3.1 First Iteration, DAMA Workshop, Tallinn, 2010

The first part of the movement documentation process started in Tallinn during the DAMA workshop. The idea behind this first iteration was to find a simple portable method for the documentation development and to produce material that could be processed in various ways in order to find an optimal postproduction method. The main goal was to convert the video material into silhouettes, whereas the important objective in the documentation process was to capture the ability of the participants to express emotions in front of the camera. Dance and theatre students are accustomed to the idea of performed emotions; however, half of the group were media students who did not have any performance experience.

The issue of body and movements was important both in the context of the workshops and the documentation process. Fortunately, DAMA workshops by tradition include physical exercises as a part of the curriculum. The physical exercises were carried out every day usually starting during the first hour of the workshop. This way the physical activities provide a good starting point for conscious integration of corporeal movement into the projects. For the emotions documentation, these exercises provided a springboard into the awareness of the body as a performative tool. The morning exercises involved Gurdjieff's method of repetitive movements, based on the idea of movement reversibility (Gurdjieff, 1933).
Management of documentation clarified the process. It was not expected that all

participating students would perform as actors and I was not interested in directing the participants but rather to document the expressions as they presented them. I discovered that my focus was on the emotions and how we perceive them. I had to ask myself whether it was important that the reflected feeling should be credible or just replayed correctly from the participants own interpretations. During the documentation process it become clear that participating students use simulated movements that represented the cultural stereotypes of how we perceive emotions mostly based on influences from movies and the media. The question of the difference between emotion-based movement and movement based on good performative techniques became relevant in these situations. However, the main issue was the participants presence; the subjective experience of participants where they themselves perform and describe the action according to their own feelings and personal interpretations.

Presence, as discussed in section 3.3 *Movements, Body Art and Technology*, was an important issue, i.e. the ability to physically interpret is connected with the ability to play, as a way to recall a state of mind that is not controlled by fear. In this context, the fear is not based on the fear of others but on fear how the others may perceive us.
Most children approach movement with flow. It is a term used by Laban in his Laban Movement Analysis (LMA), (Laban via Davies, 2006), as a part of movement aesthetics. The flow is successive when movement transfers from one adjacent body part to another, thus contributing to a continuity of movement sequences. It is simultaneous when the whole body is engaged in moving at the same time and is in a counteraction to a discontinuous, jerky movement sequence. Usually, as a person grows older the movement gradually becomes controlled and the element of flow diminishes. Flow is a dynamic movement, allowing flexibility and originality. However, during the exercises when the students find the flow through playful exercises, as described by Laban (Laban via Davies, 2006), it becomes a cohesive force that links whole-body movements and gestures, which brings balance and provides the students, previously uncomfortable with physical movement, with the ability to improvise.

The video material obtained during the workshop in Tallinn contains 10 films documenting 10 participants performing the emotion of their choice from the eight emotions of Plutchik's wheel of emotions; anger, anticipation, disgust, fear, joy, sadness, surprise and trust (Plutchik, 1984).
In the postproduction of video material from Tallinn, I focused on movements as a

performed action represented on a timeline using visualisation methods based on layers and opacity. To visualise the movements I split the video into short segments of 15-20 frames and optimised them by reducing the colour by manipulating the threshold in the Photoshop image-processing tool. The main idea of this process was to convert the material to silhouettes (black and white images), then group and compare them to one another to find the similarities (figure 4.8) among the expressions. The documentation illustrating the process is provided in the DVD/Video 2.

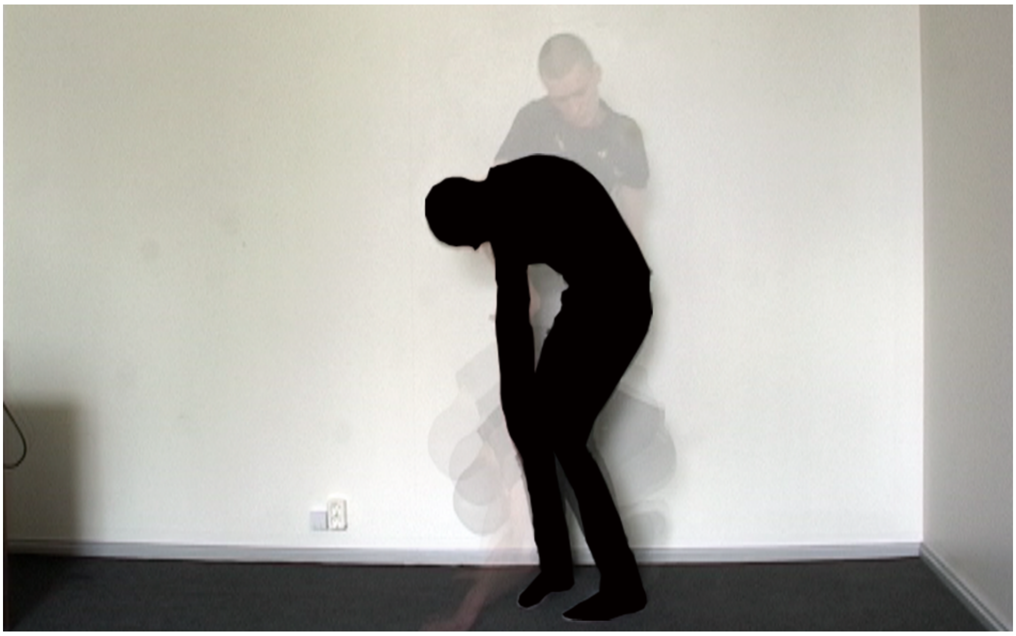

Figure 4.8 Layers of expressions; Explorations based on Tallinn workshop, Hrynczenko, 2010.

However, the recorded material was not of the quality required as movements of participants filmed against a white wall cast shadows, becoming problematic in postproduction. Consequently, the process of removing shadows became time consuming and ineffective in relation to the quantity of the material to process. Due to time limitations, the material was therefore only used for visual experimentations and not included in the final database. As a result, the findings from this recording session and the postproduction process provided a basis for a different approach in the next iteration of the movement documentation process.

4.3.2 Second Iteration, Silhouette Studio, Stockholm, 2011

The second iteration of the documentation process took place in Stockholm at the end of April 2011 when preparations were started, including equipment organisation and the building of a backlight studio. From the previous documentation in Tallinn and the process of postproduction of the material, I learnt that I should carefully prepare the best lighting set-up from the beginning to generate the best quality silhouettes required for the final video material. Therefore, in Stockholm the documentation process started with the building of a silhouette studio.

Concurrent with the studio construction the process began to find voluntary participants. The contact with participants was mainly made through the DAMA network and face-to-face conversations. The voluntary participants were performance art students, some practitioners and partly people working as writers, media artists and musicians. All volunteers had one hour assigned to both complete the questionnaire and the video recording of expressive movement. The survey was a continuation of the previous investigations of colour perception versus emotions based on Plutchik's colour wheel previously initiated in Tallinn.

During the documentation of expressive movements a Sony HDR-FX1 camcorder was used while at the same time a MacBook webcam was used for recordings of the *Shadow Dance* exercises. The arrangement with the camcorder is shown in figure 4.9.

Figure 4.9 Camcorder and webcam rig, Studio Stockholm, Hrynczenko, 2011.

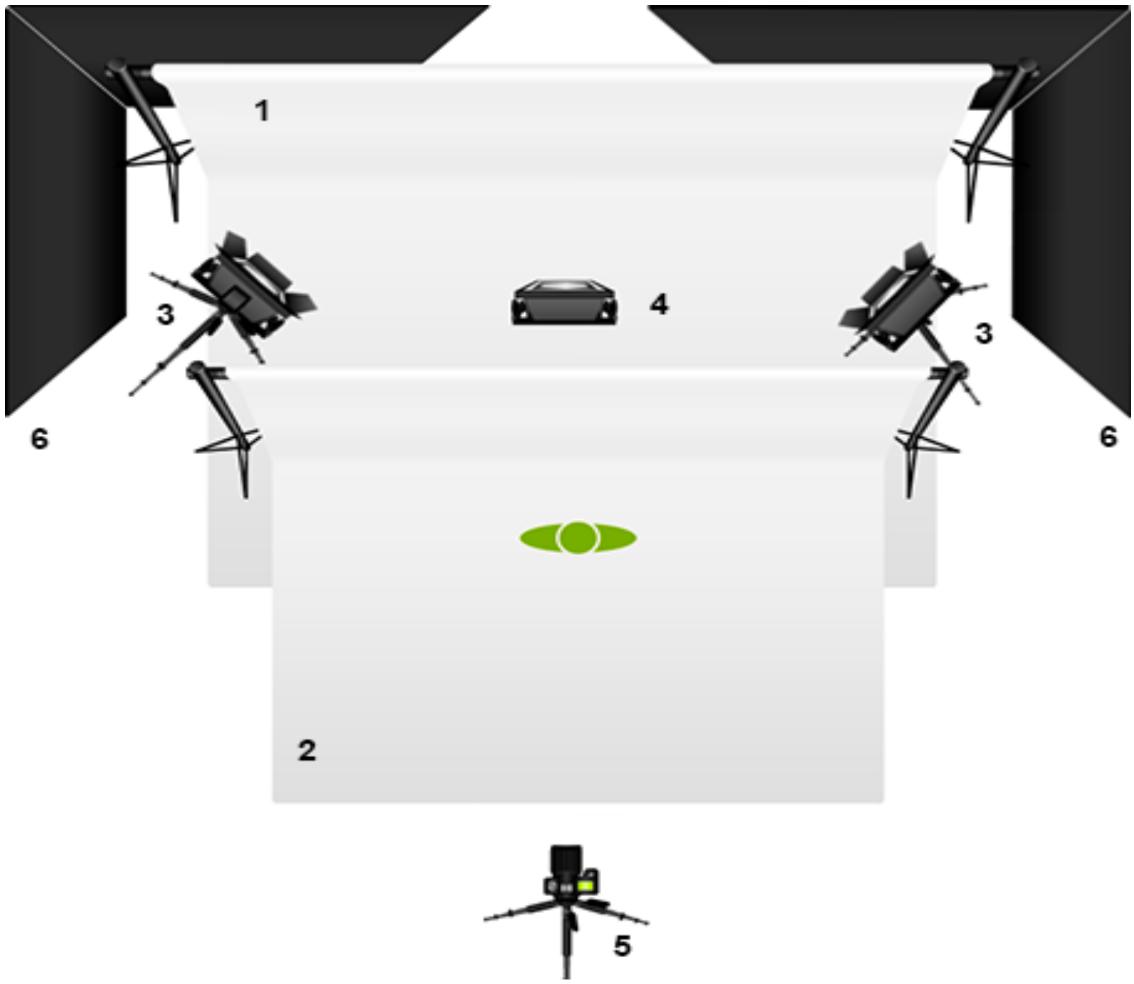

Figure 4.10 Lighting diagram; Silhouette Studio, Hrynczenko, 2011.

The studio was built according to the layout in figure 4.10 where two white backgrounds were installed, one measuring 12 feet high (number 1 in the diagram) at the back of the studio and another measuring 9 feet high placed in the front (number 2 in the diagram).

For light source, two 1000W floodlights with barn doors were used (3) combined with one 100W floodlight LED reflector. All three were placed between the two backgrounds (1 and 2) and directed towards background 1 in the diagram to get a uniform spread of light.

The video camera (5) was adjusted using light exposure settings with the purpose of finding the optimum contrast settings and to eliminate the shadows on the background (2). To absorb the light reflection from the walls black curtains were used (6). In order to eliminate the break between the background (2) and the floor, white canvas was used to extend the background over the floor. However, some problems were experienced in the process where the white floor reflected light onto the subjects, which slightly dissolved the contours of the participants' lower part of the legs in the resulting video.

The purpose of the silhouette studio was to use lighting techniques that originate from studio photography to emphasise the outline of the subject against a bright background, resulting in the type of image as shown in figure 4.11.

Figure 4.11 Silhouette Studio, Hrynczenko, 2011.

This required a long process of tests that resulted in a satisfactory video quality that could be adjusted in the postproduction process.
By the conclusion of the first five recordings I realised that the short time period was only effective with more experienced dancers. For the students and participants not familiar with performance, performing emotions required a longer preparation time.
In order to find a universally applicable approach I introduced participants to 15 minutes with the *Shadow Dance* application documented in both section 4.2 *Pedagogical Toolset* and in Appendix A. The basic idea of this visual tool was to give participants an opportunity to play with physical movement. However, the main intention of the resulting visual projections from the *Shadow Dance* application was to change the perspective on the physical body from an object to a subject in terms of bodily experience, i.e. from being 'blocked' by self-consciousness and feeling of being observed, to a creative and playful process focusing on movement and flow.

Figure 4.12 Shadow Dance; Output examples, Hrynczenko, 2011.

Figure 4.13 Shadow Dance; 70 examples of output during the workshops, (Hrynczenko, 2011.

These exercises become a ritual and a springboard into the documentation process. An example of the use of the *Shadow Dance* (Hrynczenko, 2009a) application by participants is documentated in DVD/Video 3 and figures 4.12 and 4.13.

During the recording of emotions, the participants had 30 seconds for preparation and 30 seconds for each emotion. During the session eight emotions were recorded; anger, anticipation, disgust, fear, joy, sadness, surprise and trust. The two-week session that started in the beginning of May 2011 resulted in 80 video films of 30 seconds duration of the eight emotions performed by ten participants.

Figure 4.14 Silhouette production process, Hrynczenko, 2011.

Apple video editing software, Final Cut Pro (Apple, 2010) was utilised during the post-production process. In order to convert video material to high contrast silhouettes an open-source video-filter ISilhouette (CHV-Electronics Inc., 2002-2015) was used, which helped to sharpen the lines around the moving shapes. To achieve the best result for each of the videos, these were required to be digitally cleaned of unexpected dark points and shadows (figure 4.14). However, this time consuming process made it possible to prepare the video material for conversion in ISilhouette software.

The recording sessions revealed a crucial nexus between the actual and the acted in the experience of participant performances, and sparked a reflective process during the process of editing. It was during the editing that I realised the majority of participants expressed their emotions as if learnt by watching movies. A possible explanation could be that in situations where we lack experience we tend to imitate the actions of others. This situation did not have any negative effects on the final material but has provided an additional perspective that will be considered in the final evaluation.

4.3.3 Third Iteration, DAMA Workshop, Visby, 2011

Figure 4.15 Green Screen Studio, Visby, Hrynczenko, 2011.

The DAMA workshop in Visby in early June 2011 gave me a new opportunity to complete the documentation of emotional expressions. Since I was responsible for organising the workshop, I was able to organise both space and equipment that could be used both during the workshop and the expressive movement documentation. The idea for the final iteration of the documentation process was to collect three-dimensional data of whole-body expressive movements using a motion capture studio that had been booked specifically for the ten days of the workshop. However, as there were numerous technical problems the expressive movement documentation continued as before with only a single video camera, however a *green screen* background was used instead of a white backdrop (figure 4.15).

During several filming sessions in Visby, ten participants contributed to the documentation of eight previously described emotions, enlarging the expressive movement video collection with an additional 80 videos of 30-seconds duration.

The postproduction process in After Effects (Adobe, 2011) was based on colour keying green-screening, allowing the foreground to be separated from the background based on colour data. During the process, some problems appeared in the videos, such as missing edge detail. In some videos, the edges were very pixelated based on green colour reflections on the moving bodies caused by incorrect lighting. As a result, the content of eight of the video sequences were unusable for the PTM database.

4.3.4 Comment on Recorded Embodied Emotion

During the documentation process, a variety of emmotive expressions were collected, providing several nuances of emotional intensity for each of the four emotions. The intensity of the expressions is related to the participants' introvert or extrovert personality type or cultural norm that can act as a barrier in expressing emotions (Miyamoto and Ryff, 2011; Maus, 1979/1935).

To a great extent there are existing normative behaviours that usually regulate our emotions according to the norms dictated by our socio-cultural environment. These behaviours are imposed and controlled by ourselves, however, as social psychologists Miyamoto and Ryff (2011) suggest, it is an effect of what they call "cultural scripts", a set of culturally conditioned expectations from society. These scripts mainly outline how we should experience positive and negative emotions, and how these should be balanced. Their research suggests that in the "cultural script" as observed in Western cultures, positive emotions are maximized whereas, the negative emotions are minimized. These scripts differ across cultures. For example, in East Asian cultures the "cultural script", according to Miyamoto and Ryff (2011), is to seek a middle way. In doing so, the expectation from this society is to look for the balance between positive and negative emotion. These controlling scripts are introduced to us at a very early age fostered by our parents, and we "grow into" them before we reach our teens. These socio-cultural norms can therefore sub-consciously influence the enactment of emotions, as with the workshop participants. Socio-anthropologist Marcel Mauss (1872 – 1950) describes the social environment as an imprint that acts directly on our physical body such as, for example: gait, movements, postures gestures and the way we eat or sit. Maus (1979/1935, p. 104) terms this phenomenon, formed as part of the socio-cultural legacy as "the techniques of the body". Mauss (1979/1935, p. 97) describes these adjustments to the society as: '... the ways in which from society to society men know how to use their bodies'. In other words, our bodies and through them actions are socially negotiated. Looking from the Foucauldian-somatic perspective the socio-cultural aspects of human bodily expressions are historically and politically regulated as a system of societal control. Foucault's (1995, pp. 135-169), The 'docile body' is objectified to feed a system of control.

In this respect, to help participants to overcome personal and cultural barriers that

stand between spontaneity and action, before every session the Shadow Dance application was used (referred to in sections 4.2.1 and 4.3.2).
The intention of using Shadow Dance for a preparatory exercise was to bring the participants to a state where they became attuned to the physical body, and to counteract the norms of “cultural scripts” and bodily habits (Miyamoto and Ryff, 2011) that feel unnatural and have been conditioned by other influences. However, the intention was to stop participants reflecting consciously on these forces as they were psychologically positioned outside the body and questioning themselves during the exercise: “Do I move ok? Do I look ok?” In this respect, play was used to bring the student's presence in the body, from object to subject through this mechanism. Play is a “magic circle” (Huzinga, 1955) where the participants become part of a separate space, which they share under playful conditions. In terms of *Shadow Dance* (Hrynczenko, 2009a), the only rule was to move in order to make movement traces in time and space. The issue of play is discussed in section 3.3.1 *Threshold of Presence and Space* in terms of liminality; the threshold between the real world and play or ritual in which the common, regulative social norms can be omitted. Playfulness was a core issue for every action of these exercises where participants could “paint” with their body by focusing on their body as a tool that augmented any movement. By responding to their own movement trajectories traced over time, they become playful creators. In other words, the exercise was aimed at sharpening their kinaesthetic senses and allowed participants to play with their own expressiveness in a new way, to be more extrovert and exaggerated.

The purpose of the documentation process was to collect a database of a large and diverse range of expressions which was achieved by inviting both dance students, as well as participants without dance/theatre studies training to take part in the recording sessions. The mix of participants’ backgrounds and experience provide different styles of acting and the *Shadow Dance* exercises (Hrynczenko, 2009a) introduced playfulness and movement exaggeration. In terms of the participants' movement readability for movement sensing devices, exaggerated movement was almost a prerequisite. As in animated 2D films or theatre and dance, expressions usually involve overstated gestures for emphasis.
Technique used for the creation of animated characters are explained in section 3.3.4 *Silhouettes and Expressive Movement*, and in terms of expressionist dance, debated in section 3.3.3 *Emotions and Movement*. As explained in both of these earlier sections,

the techniques applied to movement and gesture are not necessarily naturalistic. In order to augment emotions distinct characteristics of shape, space, volume, time and expressions similarities and differences, exaggeration of the expressed emotion by the performer was desirable in the context of the database.

However, movement fluidity described by Laban (Laban via Davies, 2006) as Flow differs across all the recorded video material based on the participants engagement, performing experience and personal involvement with expression. Flow as discussed previously in section 3.3.2 *Body in Motion in Timeline and Space* is a continuous and uninterrupted sequence of movement and the opposite of jerkiness, i.e. broken expressions that stop and start. Some of the recorded gestures contained a degree of jerkiness reflecting the participants different experience of performing in front of a camera, but also representative of their ability to perform emotions on demand. In many situations, it became evident that some of the participants could only act by subconsciously simulating the emotions of other actors.
From the perspective of the phenomenology of practice, Van Manen (2007) situates all actions in the context of the world as we know it and these actions are often unconsciously reflected in our bodies.

> On the one hand, our actions are sedimented into habituations, routines, kinesthetic memories. We do things in response to the rituals of the situation in which we find ourselves. On the other hand, our actions are sensitive to the contingencies, novelties, and expectancies of our world. (Van Manen, 2007, p. 22)

Correlatively, the communicative role of expressions is connected to our socio-cultural heritage that is deeply rooted in our bodies. During the recordings, it became apparent that today's media has played a major role in how we express emotions. Some of the recorded expressions while seemingly stereotypical were performed genuinely but influenced by copying aspects of our cultural heritage, a similar behaviour of copying expressions is observable in real life social interactions.
The phenomenon of copying as socio-cultural attachment is explained by Mauss (1979/1935, p. 101), as ‘collective representations’ that exist in our individual minds and are carried in our bodies. Mauss explains imitation is an inherited tool to copy successful behaviours:

> What takes place is a prestigious imitation. The child, the adult, imitates actions which have succeeded and which he has seen successfully performed by people

> in whom he has confidence and who have authority over him. The action is imposed from without, from above, even if it is an exclusively biological action, involving his body. The individual borrows the series of movements which constitute it from the action executed in front of him or with him by others (Mauss, 1979/1935, pp. 101-102).

Arguably, imitation is a socially conditioned action of the body; an expression of social codes based on shared understanding of social structures in which bodily expressions are mirroring authoritative or successful members. According to Mauss (1979/1935) the purpose of these 'prestigious' embodied imitations is an unconscious endeavour to gain an advantageous position in a social context. Today's media to a large extent have taken control of shaping normative social interactions by taking the role of the authoritative voice. In this context, drawing on Foucault's (1995, pp. 135-169) the "docile body", it can be said that our "real" bodies and bodily expressions are socially and politically controlled by the authority of the media.

In conclusion, during all three workshops, the documentation of movement was based on the participants' playful interpretation of eight emotions and not reflective of the participants' real emotional state. The documentation of exaggerated movements expressing the eight emotions is based on individual participant interpretation of the movement as if performed on stage. Exaggeration of expressive behaviour was desirable, but was not requested originally, rather these were introduced through the playfulness of the *Shadow Dance* (2009a) exercise. From the perspective of this research, a clear picture of embodied emotion was essential. In particular, the exaggeration of gestures differentiate the properties of the four emotions under study, in order to be applicable for example to game characters' walk-cycles. Accordingly, the apparent shapes of expressions potentially become identifiable by Kinect's (Microsoft, 2010) depth sensing mechanism; a technique explained in section 3.3.5 *Body, Movement and Technology*.

The documented material on the one hand, shows to what extent we are capable of recalling the idea of emotion, while on the other, it represents the socio-culturally conditioned experience; i.e. how emotions are filtered through the influence of the media.

The main technical problems encountered dring the workshops related to the various sites used for movement documentation and based on differences in studio space and lighting conditions. This affected video quality in terms of the contrast loss between the background and the body in motion. To obtain the desired sharp black and white silhouettes of the participants, some additional work was needed in postproduction requiring extra time that was not anticipated. Besides the issues with the lighting, the long postproduction process allowed only four of the intended eight emotions to be explored, namely: anger, fear, joy and sadness.

4.3.5 Comment on the Choice of Silhouettes as an Expression of Emotion

Several factors contributed to the idea of silhouettes as a final expression of documented emotions. Silhougraphs® (Keali'inohomoku, 1989) is a method used previously in an anthropological study of dance to illustrate the components of nonverbal communication in dance beyond the visual input of elements such as colours of costumes or facial expressions. Other researchers such as Knox (via Keali'inohomoku, 1989) used the method over the years as a diagnostic tool to document and estimate the progress of individuals in movement training as "before" and "after" positions. This is intended to show the changes in body styles and postures (Keali'inohomoku, 1989). The choice of method emanated from the necessary focus of this research on emotions expressed by whole body movement and gesture, where additional information from facial expressions could affect the results of the study. Silhouettes are used in both animation and the character design for games as a first step in modelling the visual characteristics and action poses of the characters. Taking into consideration the future use of the PTM database with movement sensing devices such Kinect (Microsoft, 2010), a well articulated human silhouette plays an important part in posture and emotion estimation from a single image.

Additionally, in the context of the recruitment of participants, the silhouettes provide desirable anonymity, a factor for individuals who agreed to participate in the recording sessions. To achieve the silhouette effect, adequate time for the preparations as well as for the postproduction process was required. The process be made more efficient by using appropriate lighting for the green-screen studio background and professional keying filters in Final Cut Pro or other video editing software.

4.3.6 Summary

Overall, 170 expressive movement videos were obtained based on the documentation of eight emotions—anger, anticipation, disgust, fear, joy, sadness, surprise, and trust,

performed by thirty participants in three different locations: Tallinn, Stockholm, and Visby. The documented expressions based on the actors own interpretations of embodied emotion, are acted and often exaggerated providing overstated expressions that are suitable for the final purpose of the database. Namely, as visual objects for experimentation on walk-cycles for game character development and comparative data for emotion recognition based on movement sensing devices. The first ten videos were only used experimentally in order to find appropriate methods to obtain the best lighting conditions for follow-up recordings, as well as to find suitable postproduction methods to achieve the optimum silhouette format required.
Eight videos were rejected based on poor lighting conditions during the *green screen* recordings. In order to obtain the best quality for the final video material and to shorten the extensive postproduction process, only four emotions—anger, joy, fear, and sadness were selected for conversion to silhouettes, which comprised seventy-six videos.

The decision to use silhouettes was based on many factors such as; the focus on whole body expressions, convergence with animation techniques, Kinect's (Microsoft, 2010) depth sensing technology and providing actor anonymity. The final silhouette videos are in QuickTime format (.mov), 25fps, 640 x 640 in frame size, with Pixel Aspect: Square and Compressor; Animation. During the *Expressive Movement Validation Survey* (section 5.2.1.3) and for the PTM database, the silhouette videos were created using a different, compressed file format (.f4v for Flash Player) in order to suit the requirements of the online questionnaire and database. The original output file format (.mov for Quick Time) from After Effects (Adobe, 2011) was used in VideoAnalysis (Jensenius, 2017-2012) software as a part of movement analysis and visualisation.

Summarising the output of the video recording sessions: 170 videos of eight emotions were recorded in four locations with the contribution of 29 participants. However, only 76 videos of four emotions; anger, fear, joy and sadness, were used, providing the content for the database, movement analysis and visualisations.

4.4 Movement Visualisations Process and Data Aesthetics

> *The greatest value of a picture is when it forces us to notice what we never expected to see. (Tukey, 1977. p. VI).*

In this part of the research, scientific methods such as triangulation and movement analysis are used as tools of artistic expression, while at the same time the same procedures worked as methods for explorations of both qualitative and quantitative data. Statistical data received from an online survey describes the communicative value of previously documented emotive expressions collected on 76 video clips. During the qualitative research, a triangulation method was used resulting in relational data or network data, representing similarities among emotive postures previously extracted from video material. This chapter describes only the data visualisation process in which all data is presented from its possible aesthetic value and described in this context. The data analysis and triangulation process are presented in Chapter 5 *Outcomes and Evaluation*. This way the two different processes are divided mainly to juxtapose the two different types of approach to the same material.

During the visualisation process, where emotions are visualised by means of mathematical and logical models, the challenge was to represent emotive expressions as quantitative data. Visualisations of the data collected aims to answer the first part of the research question: How could emotions expressed via whole-body movements be visually documented?

In order to provide an overview of a complex process, the question needs to be divided into sub-questions and addressed from a different perspective where "How" is exchanged with "What": What are the visual properties of emotion?
Taking into account the phenomenological “live word guides” (Van Manen, 1990) in this case literary, and against its purpose, since these become objectified, the silhouettes in motion become visible objects of corporeality.
Accordingly, the next sub-question became: What are the visual properties of emotion in terms of spatiality, temporality, relationality?

During the visualisation process, the video data collected expanded into secondary and tertiary visual structures in which the former distinguishes the similarities in movement patterns within one of the emotions, visualising the most common postures. The latter procedure categorises all groups of poses and gestures (i.e. expressions of all four emotions) and places them in relation to each other.

From the artist's perspective, the conversion of data to its visual interpretations becomes an investigation of the possibilities that arise when scientific and artistic methods are merged, i.e. the quantitative outputs are combined with the visual elements during the data visualisation process.
In this case, the expressive movement explored as patterns open the possibility to further investigate emotions that could be used as a part of interface design, extending the use of emotional expressions into the field of game design. Games are the fastest-growing medium (Entertainment Software Association via Gamebit, 2013) with strong influences on all human senses (McGonigal, 2011) and should not be seen merely as a product for entertainment, but also as a tool for information delivery in education, research, and art.
As an extension of this thought, the PTM database is intended to be used as an educational framework for game design and research. This is mainly aimed at the analysis of emotional expressions of avatars in relation to game narratives, and for the study of players' embodied emotions in the context of game *mechanics* and *aesthetics*.

This section explores data visualisation as a medium focusing on the transition of data into graphs. In this process, the graph becomes a form of expression based on its ideal, pure function or, as Deleuze described it, '…the diagram (or graph) is a set of non-hierarchical, decentralised materials and functions . . . constituting points of emergence or creativity, unexpected conjunctions, and improbable continuum' (Deleuze via James, 2009, pp. 151-155). Yet, at the same time the diagram, as I use it, is a simplification, reducing emotion to a visual element distanced from its embodied expression.

Emotions embodied in expression divided by time, space, and movement measurements suit the analytically comparative model according to parameters that describe the movements' topology, yet in this process divided from its whole and objectified.
Different techniques for visualisation are used for the different ontological visual properties of previously documented emotions. For the depiction of emotional space and expressiveness, quantitative data are converted to plots.
The idea of the diagram is a confrontation between the digital and the real, a form of

synthesis of emotions converted into numbers. It is not a notation of emotive movement in itself, but a transformation of the emotional expressions that were first converted to numbers and statistical profiles, and then to diagrams. This is a confrontation where my phenomenological approach confronts the rules of science, even if it proceeds in my own artistic way.

4.4.1 Movement Data and its Visual Interpretations

The process of data collection and its investigation and visual interpretation is divided into eight sections. In the section 4.4.2 *Colour Choice and Explorations* data visualisation techniques are explored. The sample data is taken from an explanatory investigation on the relationship of colour to emotions, in the context of the standards employed for visual concepts used for the description of emotions. Section 4.4.3 *Visual Interpretation of Survey Data*, describes the visualisation process based on the evaluation provided by an online survey, which measures the communicative value of video clips in the context of four emotions: anger, fear, joy and sadness. Section 4.4.4 *Visualisation of Kinematic Data: Emotions to Diagrams* refers to movement patterns obtained from the analysis of quantitative data from the video collection and refers to the visual properties of emotions such as space, expressiveness and time. In the fourth section 4.4.5, *Movement and Posture as Chronophotographic Charts*, the sequential movement visualisation process is presented by referring to emotions visual properties, shape and time.

During the research, quick access to the video material was needed, which provided additional tools. One is the visualisation of each of four emotions as interactive video collections described in section 4.4.6 *Movement Collections via Korsakow Interactive Database*. Another tool developed for movement analysis is the visualisation of embodied emotion expressiveness, volume and space based on video data, which is presented in section 4.4.7: *X-Ray of Emotional Kinesphere*. During the posture analysis process, the postures of four emotions were converted to skeletons in order to simplify the expressions and to find the common denominators in terms of the emotions' shape. This process is described in section 4.4.8*: Shape and Skeletons: Posture Comparison Process* where outputs have provided correlation data for visualisation presented in a *Periodic Table of Human Movements*. This final output of the research is based on previous visualisations and a triangulation method described in the evaluation process presented in Chapter 5 *Outcomes and Evaluation.* However, the final visualisation process is a correlation table presented in this chapter and described in the section 4.4.9*: Visualisation of Periodic Table of Movements.*

The investigation of colours versus emotions during the first part of the research served as a guide to qualitative methods based on questionnaires in which correlations between colours and emotions were investigated. In this part of the study, the aim was to explore data visualisation methods. Expressive movement analysis and their aesthetic interpretation are an exploration of scientific data as visual objects. The same visual objects serve as a validation of the previously collected video material and are based on statistical data retrieved from a survey on emotion recognition.

The expressive movement visualisation process became a part of the research aiming to expand the perception of movement and gesture by creating a different approach to existing values and cosmologies.
In my attempt to find a continuum of experiential qualities, the visualisations are based on data collected by two methods: an online survey and video analysis. Both methods produced quantitative data that are used in the statistical analyses and visualisations.

The aims of the visualisations of the statistical results are:

1) To explore tools for data visualisation.
2) To explore the aesthetics of data in the context of corporeal movement and emotions: anger, fear, joy and sadness.
3) To find methods for the documentation of embodied emotion in terms of its visual qualities such as volume, space, time and these communicative values.
4) To make quantitative data of the expressions' communicative values on each of the video clips understandable for database users.
5) To use data visualisations as explorations of the database as useful information for further research.

4.4.2 Colour Choice and Explorations

Visual perception of colours appears to be an important part of visual input in all digital media sources. The psychological values of colours were described by Johann Wolfgang von Goethe in his *Theory of Colours* (Goethe,1810), in which his poetic descriptions bring depth to colours' cultural values and colours in nature. Similarly, Edwin Morgan's *Colour Poems* (Morgan,1978) in silkscreen prints, reflect the depth of the boundary between colour and its metaphorical associations based on culturally rooted symbolism. The *Colours and Emotions Survey Experiment* described in section 5.2.3, evaluated the method for data visualisation and provided direction for a more comprehensive investigation of emotion recognition of whole body movement. However, I did not continue with an extensive study of colours versus emotions comparability since I found an existing study in this area; namely, the research of graphic designer Orlagh O'Brien presented as an online artwork in *Emotionally Vague* (O'Brien, 2007).

The important reflection in this context is that her work inspired the direction of the design process in this research, namely, to use a different approach in terms of the visualisation of statistical data and movement analysis. In particular, the decision to use graphs as an extension of movement illustrates where the colour of graphs reflects the colour of the emotion investigated. Plutchik's psychoevolutionary theory of emotions (Plutchik, 1984) is one of many existing theories on emotions. However, my choice to use it as a primary grounding principal for the design of the PTM database is based on his classifications of basic emotions and his use of colours as analytic concept descriptors.

The colour tagging of emotions used in a majority of my data visualisations is based on the existing use of specific colour combinations as applied to emotions as a concept. Primarily this is based on Plutchik's (2003) use of colour applied as a metaphor in a scientific analytic presentation of the diversities among emotions. Secondly, my choices are underpinned by the research of O'Brien (2007), a visual artist, which investigates colours as an interpretation of emotion. In Plutchik's (2003) Colour Wheel of Emotions, the emotions are conceptualised in terms of similarities and opposites. Mainly, Plutchik uses a metaphor of equivalent and complementary colours and their combinations in the classic colour wheel as an analytic tool to present his idea of eight basic emotions and correlated secondary emotions.

O'Brien's (2007) qualitative and quantitative study: *How do you ask a stranger (not necessarily fluent in English) to recall and describe their private emotions?* examines embodied and non-verbal qualities of emotions based on a survey that provided answers from 250 men and women from over 35 countries. Plutchik's (1980) colours of emotions as a metaphor has a similar outcome as O'Brien's study where emotions are perceived as colours, and both approaches are discussed in section 3.2.5 *The Resonance of Art.*

Grounded in the compatibility between these two methods of approaching colour in the context of emotion, I use the same colour combination such as: red for anger, green for fear, yellow for joy and blue for sadness. The aim of this approach is to differentiate the visual properties of these four emotions in a tagging system for the database. This is acheived mainly, in the majority of graphs that present the statistical data, and as well as in the final visualisations of posture correlations; A Periodic Table of Movements.

The same correlations between colour and emotions are used in previously described artworks such as: *We Feel Fine* (Kamvar and Harris, 2006) and in *Cymbolism* (Suffolk Software, 2008) as described in section 3.2.5 *The Resonance of Art*. With some small differences in hue value, brightness and saturation these artworks use colour combinations that correspond to the four emotions investigated in this research. This choice is mainly based on the metaphorical value of colours used for a conceptual description of emotions already used in design. Perhaps with the gradual introduction of a tagging system for emotions, there is a need for a descriptive, visual standard for emotions. The approach is not artistic, nor scientific, but rather schematic and suitable for data visualisation. However, besides the standardised colour tagging of four emotions, different colour schemes are used to show other data parameters. These colours are my subjective choice in which I often explore a different colour combination in relation to the four standardised colours of emotions. An example of these variations is shown in the next section 4.4.3 *Visual Interpretation of Survey Data*.

The study that took place during the DAMA workshop in Tallinn was an exploration of the relationship between colours and emotion based on Plutchik's (2003) Colour Wheel of Emotions. One of the reasons for this study was my curiosity about if Plutchik's (2001, p. 349) metaphorical colour classification has a connection to how we perceive symbolically colours in relation to emotions. To some extent, the perception of colours as emotion was correlated to Plutchik's conceptual table of colours and emotions confirmed by O'Brien's (2007) research. A parallel track was to explore data in terms of how we experience colours in relation to emotions, in terms of gender, cultural and geographic parameters. However, The main aim of this exercise was to gather quantitative data for explorations of data visualisations methods.

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The output of this exercise is represented as charts in Appendix J: *Statistic Data Samples for Plutchik's colour comparison*. In the study, only eight basic emotions were used in reference to the second circle in Plutchik's Colour Wheel chart.

The colour evaluation generated new insights that have influenced the strategy of the database design in terms of the use of colours as part of interface design. In this case, four colours; yellow, red, green and blue become key elements that describes four different emotions. In the context of the PTM database, colour labelling will be an important factor for future feedback systems in the context of movement sensing devices. For example, expressive movement recorded by movement recognition devices could be amplified via feedback in the form of colour projections or artefacts that correlate to the colour system and emotional expressions as described by Plutchik (2003), i.e. colours versus emotions in his Colour Wheel.

As discussed in section 3.2 *Emotions, Science, Art and Virtual Worlds* there is no definitive theory of emotions or how emotions relate to our perception of colours except for culturally assigned symbolic values, similar to the ideas presented in *Colours in Culture* by McCandless *et al.* (2009. In the context of the PTM database design, the open form of its construction allows additional material to be added for on-going research and future reference.

4.4.3 Visual Interpretation of Survey Data

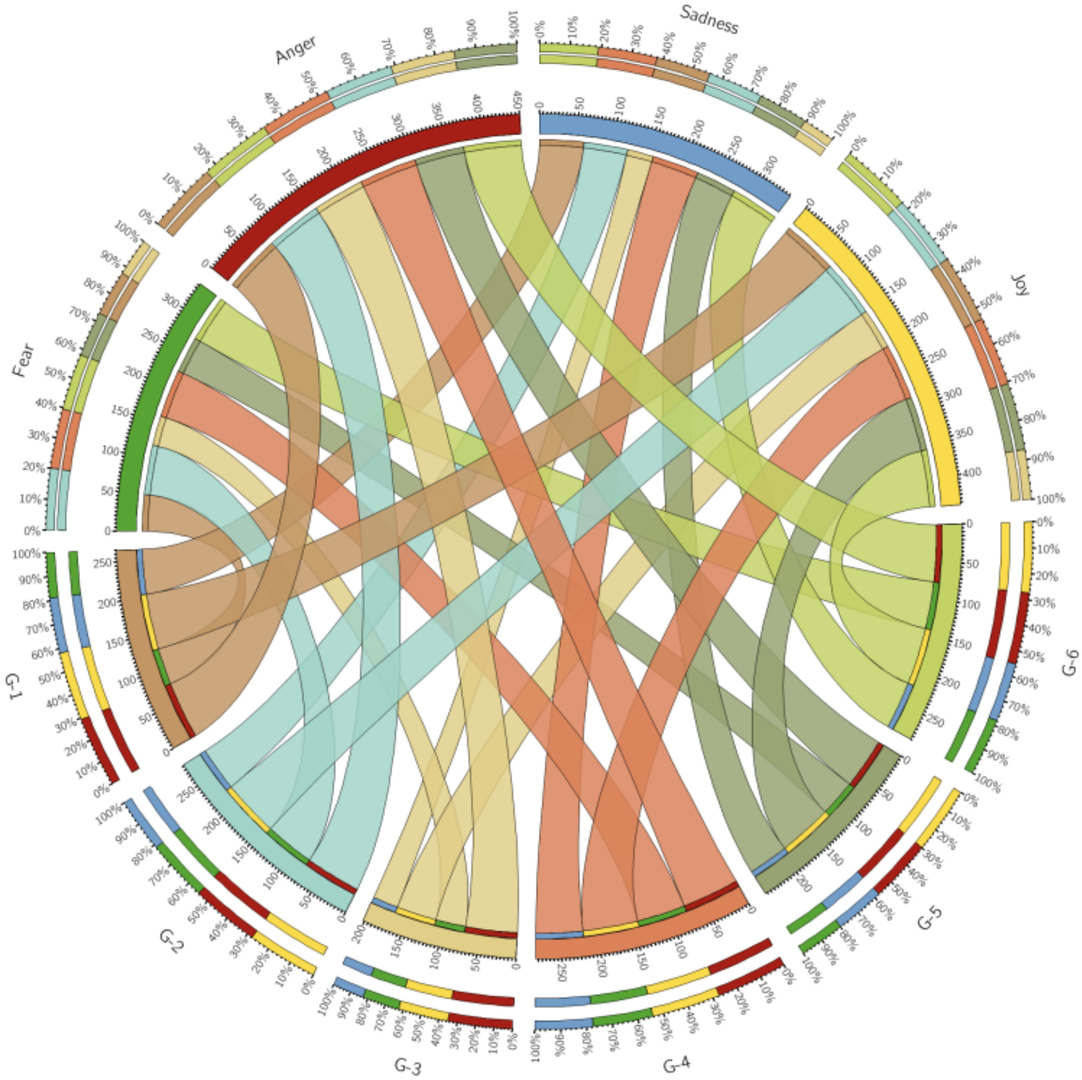


Figure 4.16 Circos visualisation example of survey data evaluation, Hrynczenko, 2013.

The investigation of emotions as silhouettes in motion is partly driven by a search for arguments that confirm that physical whole body movement and gesture are of substantial importance, as a communication tool between humans. Therefore, the online survey was conducted in order to determine to what extent it is possible to recognize bodily expressed emotions without access to facial expressions while only using human silhouettes. At the same time, the survey aims to validate the collected video material as material for the database while providing a visual tool that database users could use to organise video clips. In this case, the relationship between the performed emotion and the recognition factor for each video clip serves as a search parameter in the PTM database.

4.4.3.1 Statistical Data to Graphs

The numerical data obtained from the Expressive Movement Evaluation Survey (EMES) represented answers from 25 participants. The data was divided into tables according to 4 emotions and processed in Excel (Microsoft, 2011a) for further transformation to graphs. The statistical tabular data computation was based on both mean calculation by adding a group of numbers together and then dividing by the count of those numbers, and mode calculation that represents the most frequently occurring number in a group of numbers. For visual comparison and aesthetic purposes the results were translated to a specific form of tabular data and further processed in the Circos visualisation software package (Krzywinski *et al.,* 2009). However, the Circos libraries can only be executed through the Perl (Wall, 1987) programming language.

The graphs also became part of the final database providing additional material for expressive movement analysis since the circular format of Circos, as the developer Krzywinski (2012, unpaged) explains '… is ideal for exploring relationships between objects or positions'. The software package was originally developed to suit the visualisation of biological data in comparative genomics, yet during the last few years its visual popularity has expanded into other scientific and non-scientific areas.

The charts produced in Circos (Krzywinski *et al.,* 2009) were transferred to Flash (Adobe, 2009) by using the software's ability for interaction. This approach provided the PTM database with an interactive *Chart Comparison Application.* The application supplies PTM with a search function that together with the movement timelines is a simplified overview of the statistics of the emotion recognition factor. More detailed information about this feature is provided in section 4.5.4 *PTM, Information Visualisation.*

4.4.4 Visualisation of Kinematic Data: Emotions to Diagrams

Video analysis based on software for movement analysis within digital video was used in order to find patterns, similarities and differences in expressive movement that are specific for each of the four emotions; anger, fear, joy and sadness. The main idea of the data visualisation was to look at emotion as movement converted to numbers i.e. digital data as discussed in section 3.4.2 *Bridging Boundaries: body>data>body*. The perception of emotion converted to numbers, represented as charts and their subsequent evaluation, reflects the digitisation process. In order to convert corporeal movement from visual information, i.e. bitmap data to numerical data, the software VideoAnalysis (Jensenius, 2017-2012) was utilised. The software, as described by Jensenius (2007), supplies non-real-time video analysis, providing both visual and quantitative data in the form of motiongrams and numerical data based on several movement parameters that can be executed from the video file.

The VideoAnalysis (Jensenius, 2017-2012) program was developed as a part of the Musical Gestures Project (2004-2007), a research study at the Department of Music and Theatre, University of Oslo, where Jensenius is the Head of the Musicology Department. Software development was based on studies of embodied perception and cognition in music and with Max/MSP/Jitter (Cycling '74, 1997). The main aim of the research program, The Musical Gestures Project is described as follows:

> *Work towards a coherent theory of the relationship between musical sound, human gestures and musical concepts*. This means making a broad survey of music-related gestures in view of accumulating systematic knowledge of what kinds of gestures are actually made (and/or imagined) by musicians, by listeners, by dancers, etc., in other words to give more explicit representations of what is often "tacit" or "procedural" knowledge (Aksnes *et al.*, 2004-2007, p. 2).

The choice of the software for movement analysis originates from the information gained during the contextual review; mainly drawing from the observation that movement recognition research is widely developed and discussed (Mazzola *et al.*, 2012; Aksnes *et al*., 2007) in the area of musical gestures where the focus seems often to be on the analysis of gestural movement.

The VideoAnalysis program (Jensenius, 2007-2012) outputs horizontal and vertical motiongrams and converts the movements registered on video file to numerical data based on time, xy position, xy velocity, absolute velocity, direction of the movement, absolute acceleration, change in direction, and quantity of motion (QoM) where QoM represents the sum of all active pixels in a motion image. In practice, 0 is equal to no motion and a positive value represents motion in any direction. QoM is used for the analyses of an expression's intensity in relation to the movement's timeline.
Extended technical information features are provided in Appendix K together with an extended description of the data generated by VideoAnalysis (Jensenius, 2017-2012).
In terms of this doctoral study, the program provided the technology to capture and

present physical movements as qualitative numerical data in graph and animation formats that in turn became an effective tool for data analysis and movement classifications. Two types of data visualisation are meaningful for the movement data information; scatter graphs for the x,y position (figure 4.17) and the quantity of motion (figure 4.18).

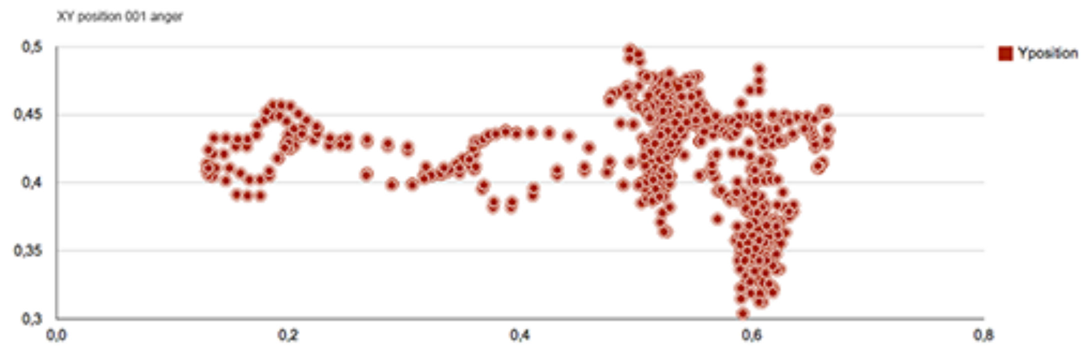


Figure 4.17 Movement visualisation example based on xy position, Hrynczenko, 2013.

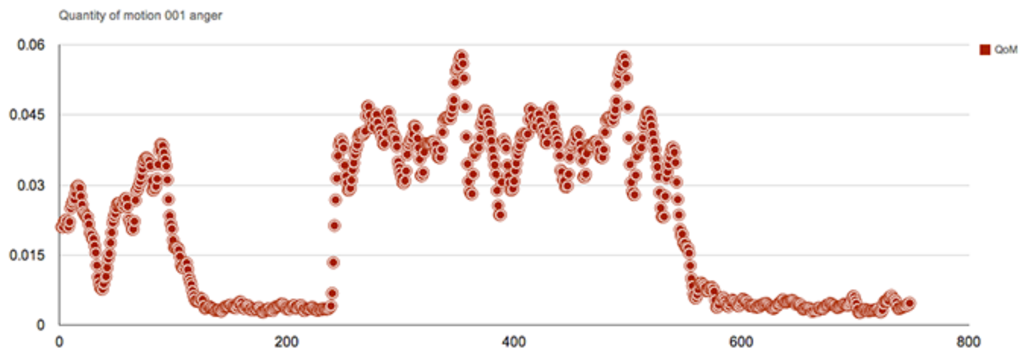


Figure 4.18 Movement visualisation example based on quantity of motion and time, Hrynczenko, 2013.

Both diagrams are based on Cartesian coordinates such as the value for x = horizontal position and y = vertical position.
The visualisation process is based on kinetic data delivered from movement identified on each single frame of video. The output is the median (all movement points in the frame divided by its sum) for that particular frame. The output of movement parameters is collated in separate columns of a spreadsheet.

All columns of data were transferred to a data sheet to estimate the plot points of each frame. In order to determine the intensity of the movements, the quantity of motion data was converted to a scatter diagram together with the number of each frame, so that the x-axis represents the number of the frame, which gives an orientation of time, and the y-axis shows the quantity of motion in this frame. Both diagrams provide an orientation on movement patterns for each participant and emotion. The chart function in Google

Spreadsheet (Google (2012) was used for conversion from numerical data to a scatter graph. I chose this tool from an inventory of different software options investigated based on my requirements. My parameters for this investigation were: the amount of data that could be uploaded and analysed, the possibility to make colour adjustments and the quality and size of the graphs. The graphs are saved as PNG (Portable Network Graphics) images and compiled in Photoshop to highlight movement patterns that are specific for each emotion as database content. All diagrams are colour tagged according to the emotion's colour.

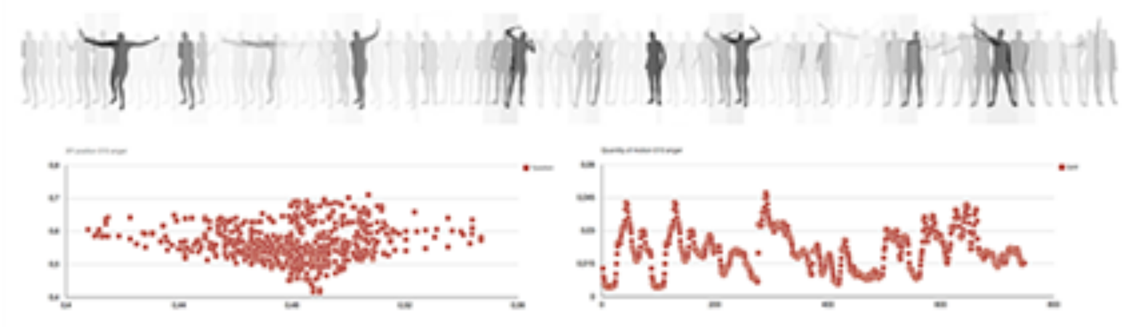


Figure 4.19 Example of artefacts used for triangulation, Hrynczenko, 2013.

The visualisation of expressive movement bitmap data provided 152 charts that encompassed diagrams for each documented participant and each emotion, and contained in the database as chart collections. This structure is constructed by visual input of the characteristics for each emotion for comparison with the specific style of performers movement visualised in the chronophotographic timeline charts (figure 4.19). A triangulation method described in section 5.2.4.10 *Triangulation, Quantitative Analysis of Visual Data*, based on this comparative visual analysis, is used to estimate the characteristic movement patterns for each emotion. Specific movement patterns were then highlighted in Photoshop on the chronophotographic timeline charts.

4.4.5 Movement and Posture as Chronophotographic Charts

Visual movement/posture analysis provided an additional method to highlight several phases of movement according to the video timeline. During the first phase, superimposed video frames were converted to a series of still images. In the next step, these were combined in Adobe Photoshop into a single image building a chronophotographic chart (figure 4.20), a process that aimed to visualise the movement over the time.

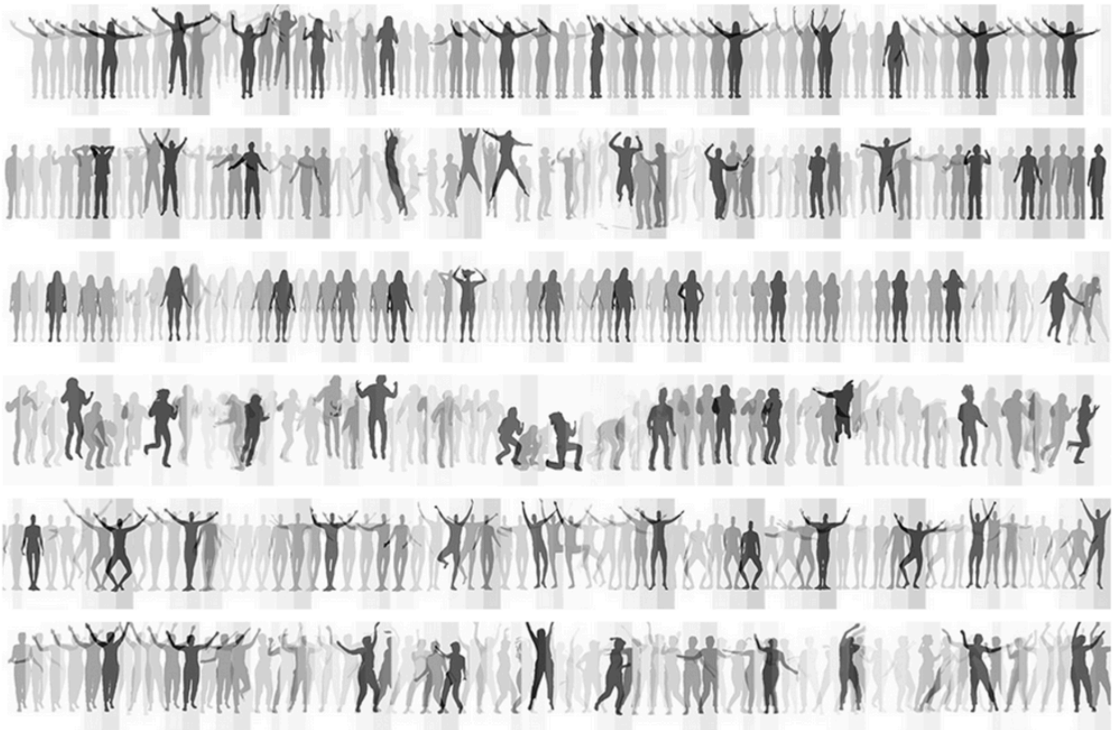
The method was inspired by chronophotography. In the case of this study, the

chronophotography was used to analyse the different poses and gestures for the four emotions. This approach makes it possible to see the movement in the context of time as a panoramic representation of expressed emotion.
This method combined with Keali'inohomoku's Silhougraphs® (1989) allowed the specific posture of a silhouette to be seen in the sequential context of time. This procedure makes it possible to analyse different poses and, as an effect of the triangulation, highlights those that are most characteristic for the emotion and the performer.

The study on movement characteristics is exploratory and interpretative in its nature and based on the visual analysis of expressions specific for each emotion. In regard to the PTM database, the chronophotographic charts are presented as collections of movements according to each emotion, which allow the users to quickly understand the content of the original video. In addition, the charts can be used to quickly compare the silhouettes in order to find similarities among expressions for each emotion.

In summary, during the *Spatial and Visual Data Analysis* process, the chronophotographic charts were used in the comparison method together with motion graphs, aimed at finding postures that were often repeated across video clips. In the final stage, these numerous postures were categorised according to how extensively they were representative of each of the emotions and if these visual properties could work with movement sensing devices. In the process of categorisation however, it becomes obvious that several of the emotive expressions are uniquely based on the personal characteristics of the person expressing them of which the chronophotographic charts provide an overview. In terms of future adaptation for use with Kinect (Microsoft, 2010), the chronophotographic charts provide sequence matching in which the action of the player's movement sequence can be recognised. For character development in games, the charts provide walk cycles, i.e. flow schemes.

Joy



Fear

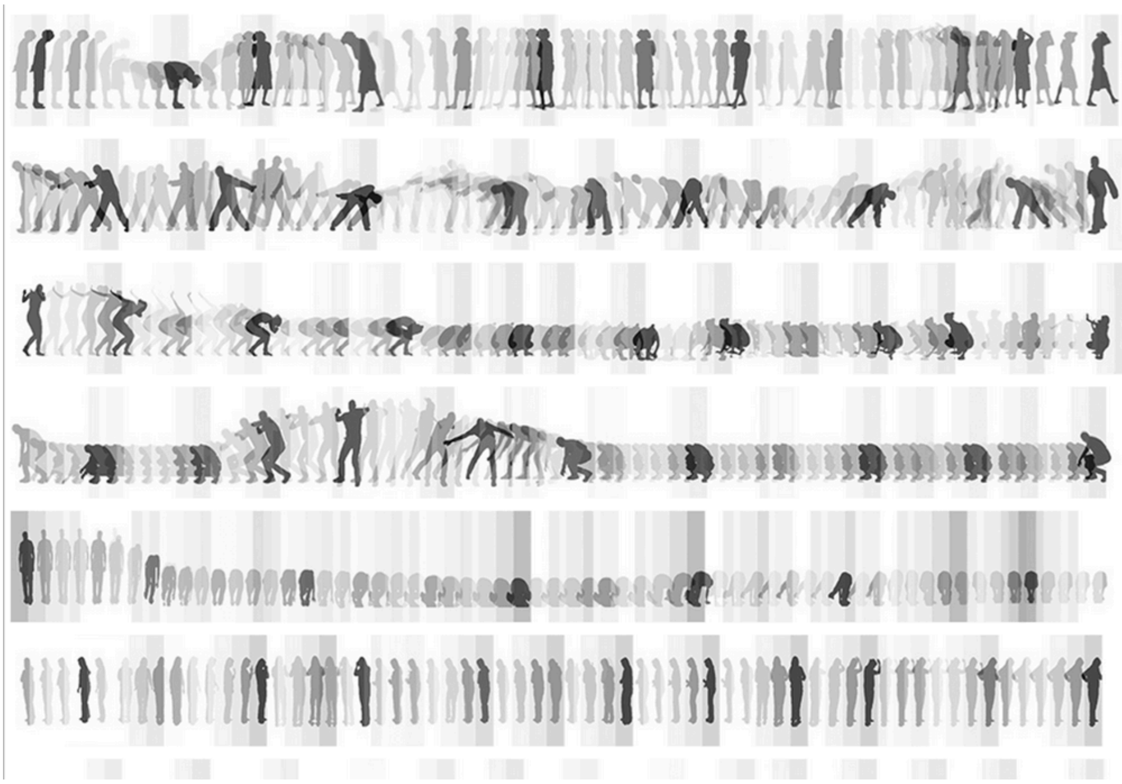


Figure 4.20 Example of chronophotographic timeline charts, Hrynczenko, 2012.

4.4.6 Movement Collections via Korsakow Interactive Database

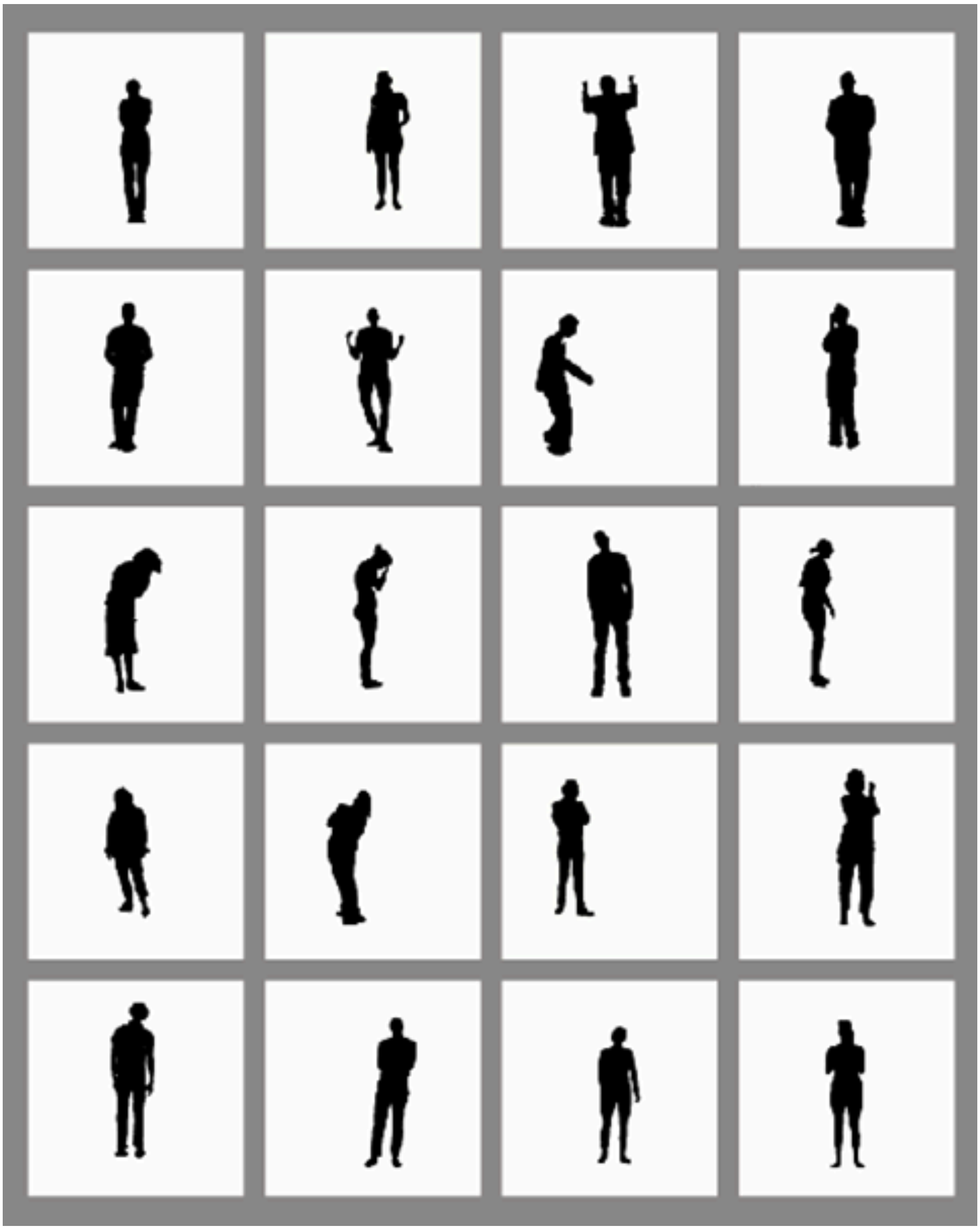


Figure 4.21 Expressive Movement Collections quiz; showing ‘anger’ silhouettes, Hrynczenko, 2013.

The Korsakow System (Thalhofer, 2007) is a tool for the creation of film databases that allow nonlinear and interactive narratives to be developed. This feature was used to create interactive video collections where users can navigate from one collection to another (figure 4.21). The intention with each approach was to provide an overview of all possible expressions in motion with a user-friendly interface, whilst at the same time using the features of a simple quiz game.

The collections are a part of the PTM database and present all 76 video clips allowing a quick overview of the content of each video. By using the "mouseover" function, users can view each of video clips in a preview mode providing quick access to the video content. To navigate from one collection to another, a quiz system is used which in turn requires that users identify emotional expressions from the silhouettes movement in order to progress to the next collection.

In each of the four collections, one of the video clips represents a different emotion. The users can move to the next collection only by clicking on one of the figure tumbnails that differ from the others in terms of the emotion represented. Using this approach, users must search the collection in order to move to the next one, which in turn provides users with a better understanding of potential relationships among emotional expressions.

The application is also used in the study of the generic representation of postures in which the focus is on differences and similarities among expressions, investigated via a method of triangulation. In this process, movement collections were used to generate thumbnails that represent the expressiveness characteristics of each of four emotions, and in the context of the expressions usefulness for optical, movement sensing devices. Those in turn, provided a basis for future steps in the triangulation process outlined in the section 5.2.4.10: *Triangulation, Quantitative Analysis of Visual Data.*

4.4.7 X-Ray of Emotional Kinesphere

The visualisation of personal space (i.e. the volume of emotion), on the one hand, showcases how movement documentation material could be applied using the PTM database framework. On the other, it illustrates the emotional and physical space of each of the performers that contributed to the video material.

My intention in this part of the project is to show both the potential of the PTM framework, as well as document the intensity of expression and its volume by using only one image. This provides potential for its future use both for game character development and for sensing devices.

The idea is based on the "movement architecture" of a personal space, defined by Rudolf von Laban (1879–1958) as kinesphere, (reviewed in section 3.3.2 *Body in Motion in Timeline and Space*) and Oskar Schlemmer's (1888–1943) concept of

Egocentric Space-Delineation (Schlemmer, 1924,) explored in his artwork as previously mentioned in section 3.3.7 *Movement Recognition Technology and Art*.

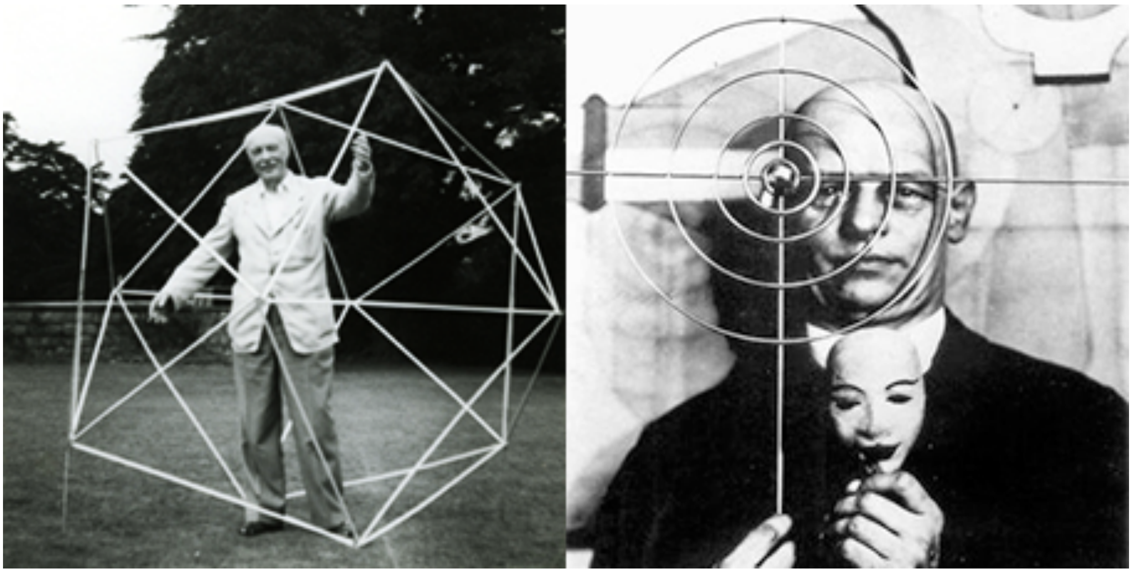


Figure 4.22 Laban inside Icosahedron, 1955 and Self portrait, Schlemmer, 1931.

In the context of this project they both have a unique relationship to movement, space and volume, as depicted by the two portraits in figure 4.22. These provide, a view on movement perception in relationship to space, Laban's based on geometry and Schlemmer's on body volume and outline.

I have chosen to experiment with visual aesthetics that originate from science (biology, medicine) in order to integrate the scientific image with the aesthetic view, an attempt to bridge between the two. X-ray of Emotional Kinesphere is an elaboration on expressive movement emphasising the personal space as a combination of space, body, and time. In this phase of the research, three of the four themes based on the phenomenological heuristic model are applied as guides emphasising lived space (spatiality), lived body (corporeality), lived time (temporality), and lived human relation (relationality or communality) (Van Manen, 1990).

The visualisations were generated by using the process of compression from 750 frames to a single frame illustrating an X-ray of emotional space via motion compressed to one still image, centered around the z-axis along the image plane of all 750 frames, a process repeated for each of the 76 videos (figures 4.23 to 4.28).

Figure 4.23 X-ray of emotional kinesphere; 015_joy, Hrynczenko, 2013.

This technique made it possible to emphasise emotional expressions in relation to kinesphere, an “extracorporeal space” (Paillard, 1987, p. 43). For this purpose, ImageJ image processing software (Rasband, 1997) was utilised with a Z-Project filter specifically developed for the analysis of changes in an image series, based on standard deviation of time frames that forms the z-axis of all frames of a particular video. The Z-Project filter is frequently used in medicine and biology for analysis of fluctuations in the skull and bone structures in x-ray images. ImageJ (Rasband, 1997), developed at the National Institute of Health, is a public domain, image processing software based on Java and originally used for image analysis in microscopy (i.e. bio-techniques).

The adoption of tools for image analysis, which originates from a laboratory environment, reflects my need to analyse emotional expressions the same way as human tissues are analysed in modern laboratories.

Figure 4.24 X-ray of emotional kinesphere; 004_sadness, Hrynczenko, 2013.

This way, the emotion symbolically becomes a part of a human body in which the visualisations emphasise the movement space as an attempt to showcase the architecture of movement particular to each emotion in relation to the performer's individual kinespheres. In the visualisation process the time axis (z = 750 frames) provides movement traces that describe movement volume in space over time by forming patterns displaying movement architecture disclosing the emotional kinesphere's x-rays.

Figures 4.23 and 4.24 showcase two of 76 x-ray images whereas figures 4.25 to 4.28 represent the collection of all x-rays emphasising the kinespheres of each of the four emotions. This way, the emotion symbolically becomes a part of a human body in which the visualisations emphasise the movement space as an attempt to showcase the architecture of movement particular to each emotion in relation to the performer's individual kinespheres.

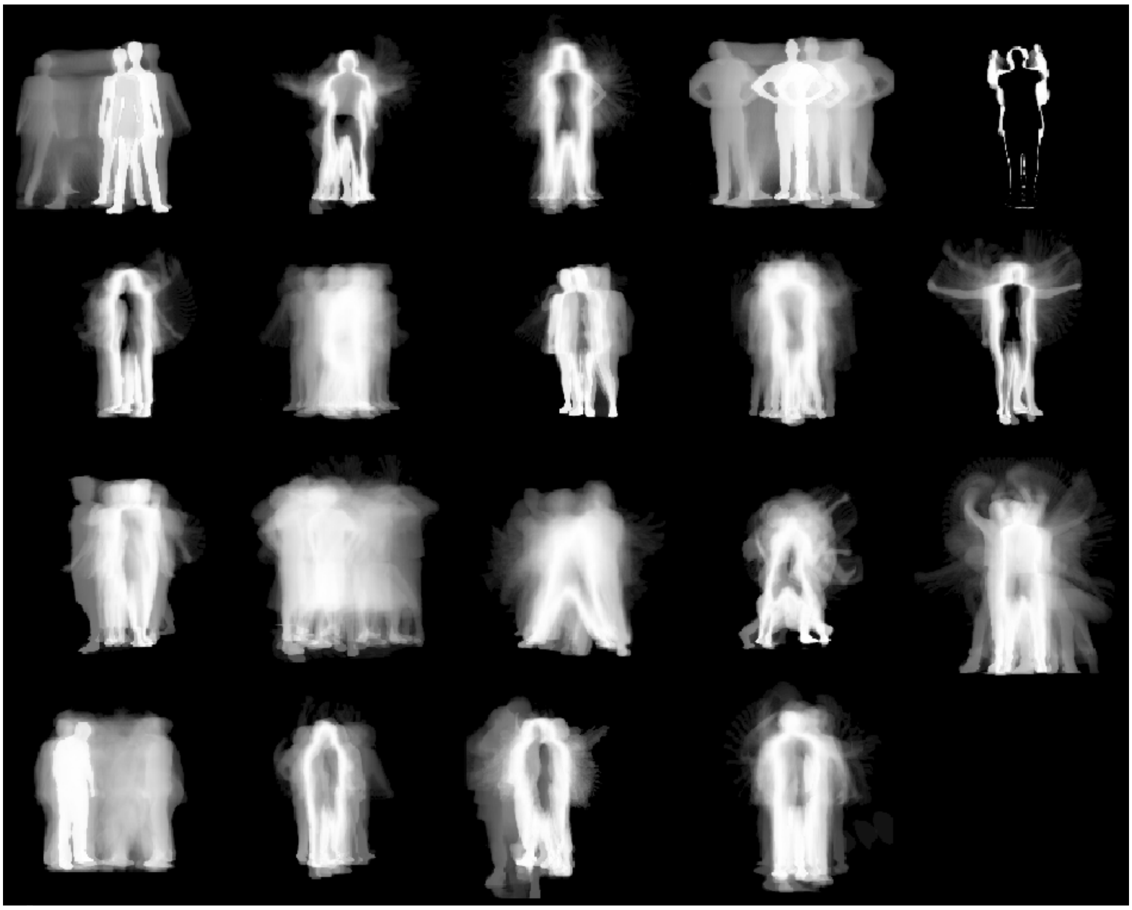


Figure 4.25 X-ray of emotional kinesphere; Anger, 19 actors, Hrynczenko, 2013.

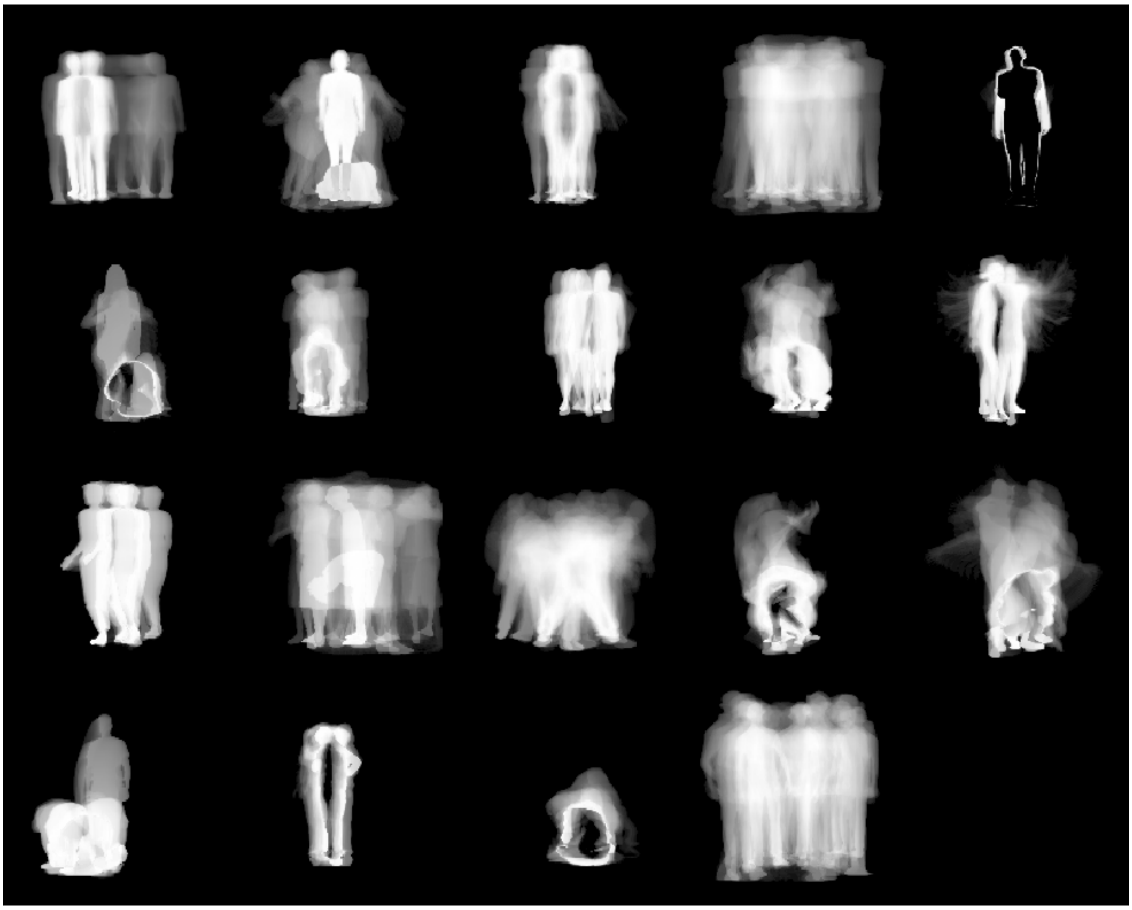


Figure 4.26 X-ray of emotional kinesphere; Fear, 19 actors, Hrynczenko, 2013.

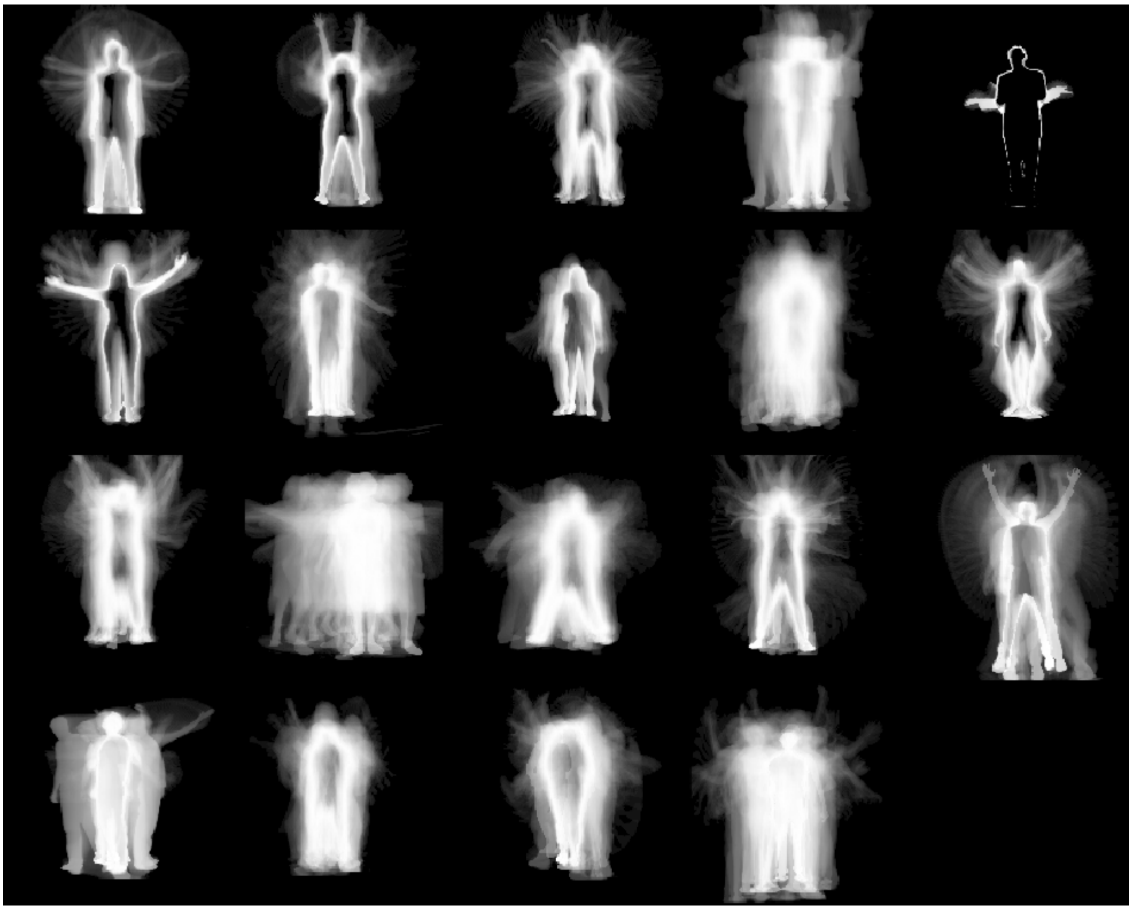


Figure 4.27 X-ray of emotional kinesphere; Joy, 19 actors, Hrynczenko, 2013.

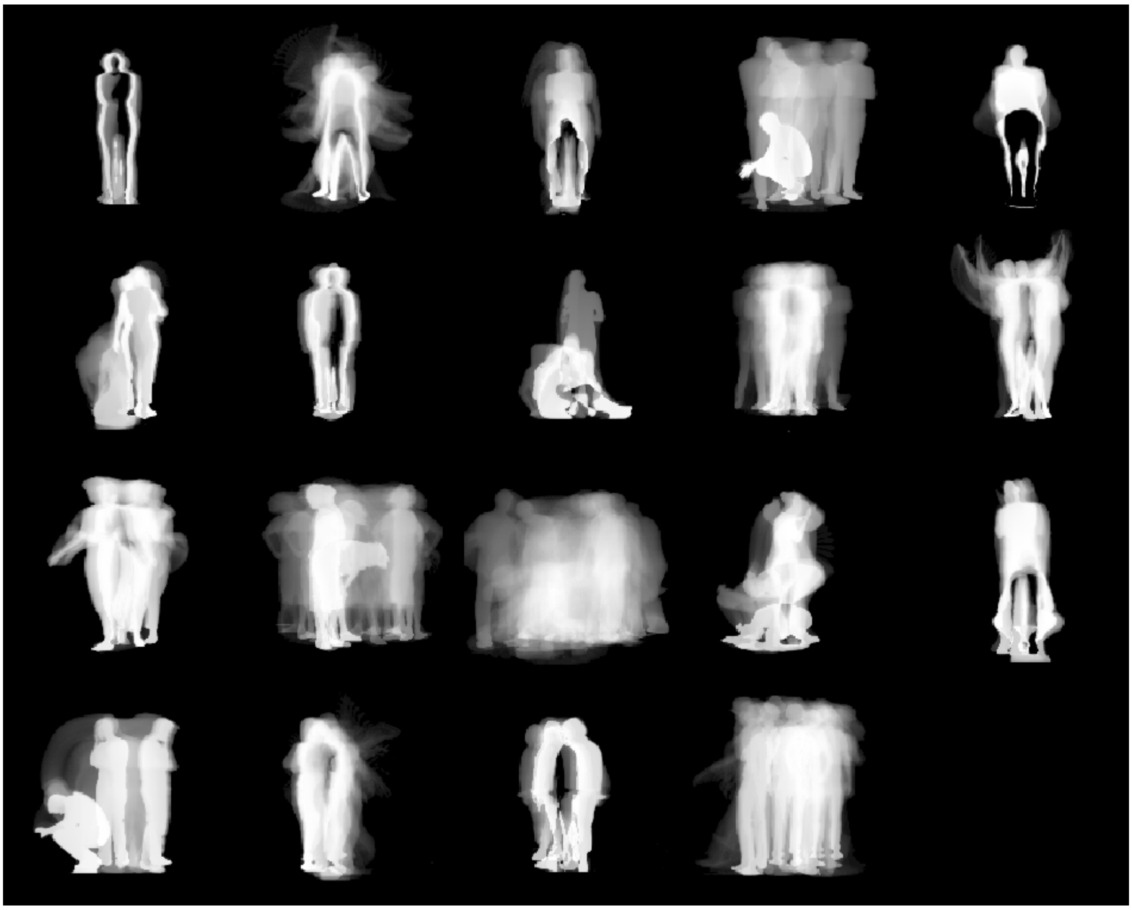


Figure 4.28 X-ray of emotional kinesphere; Sadness, 19 actors, Hrynczenko, 2013.

From the ontological perspective, this single study looks at what the visual properties of emotion are in the context of character development and expression readability for movement sensing devices. The focus in this part of the study is on the space and volume, based on the movement's trajectories traced in space and time; a visual imprint left by movement over 30 seconds of time in this case. The multitude of traces of movement encompassed in a single image was achieved by an automated process utilising computer software. In this process, the computer programme compressed together each tenth frame of video using an automatically selected variable setting for the opacity layer. The same opacity value was applied to all video data, utilising this setting that was intrinsic to the software and executed automatically.
The perception of the "ornamental" aesthetics that the image creates could be accounted for by the artist's interpretation; yet, it is only a computer processed documentation of movement when traced over the time. The images captured the participants very subjective interpretations of emotion and their movement's expressiveness, i.e. their physical engagement in the emotion being expressed; most notably, how the volume of emotion is created.

4.4.8 Shape and Skeletons: Posture Comparison Process

The main purpose of posture comparison was to find characteristic expressions in the video data sample, both for each emotion, and for the correlations among expressions across all four emotions. The analysis of postures proceeded in terms of postures expressiveness in the context of character development and expression readability for movement sensing devices. Consequently, in order to find the differences, further processing of video material contained in the database was required. The central part of the process was skeletonisation. In this part of the study, a visual classification method is examined as necessary for the data visualisation of posture correlations. The Posture correlations table; Periodic Table of Movements is intended to provide the basis for the game character's choice of posture based on the context of character dialogue within the game animation. Additionally, it provides visual comparison information for Kinect's (Microsoft, 2010) Depth Stream (depth data) and skeletal tracker, (function described in section 3.3.6 *Technology; Perceptual Interfaces and Movement Recognition*). The study is explorative in its nature and focused mainly on the visual classification methods used in the fields of HCI, biology, and medicine where often mechanical and microscopic imaging is used.

Skeletal tracking is a part of Kinect's software development kit (SDK), which makes the skeletonisation process an essential part of posture/movement recognition. Kinect's SDK translates silhouettes to skeletons in real-time which provides readable movement tracking information for game engine data. After Microsoft released Kinect in 2010,

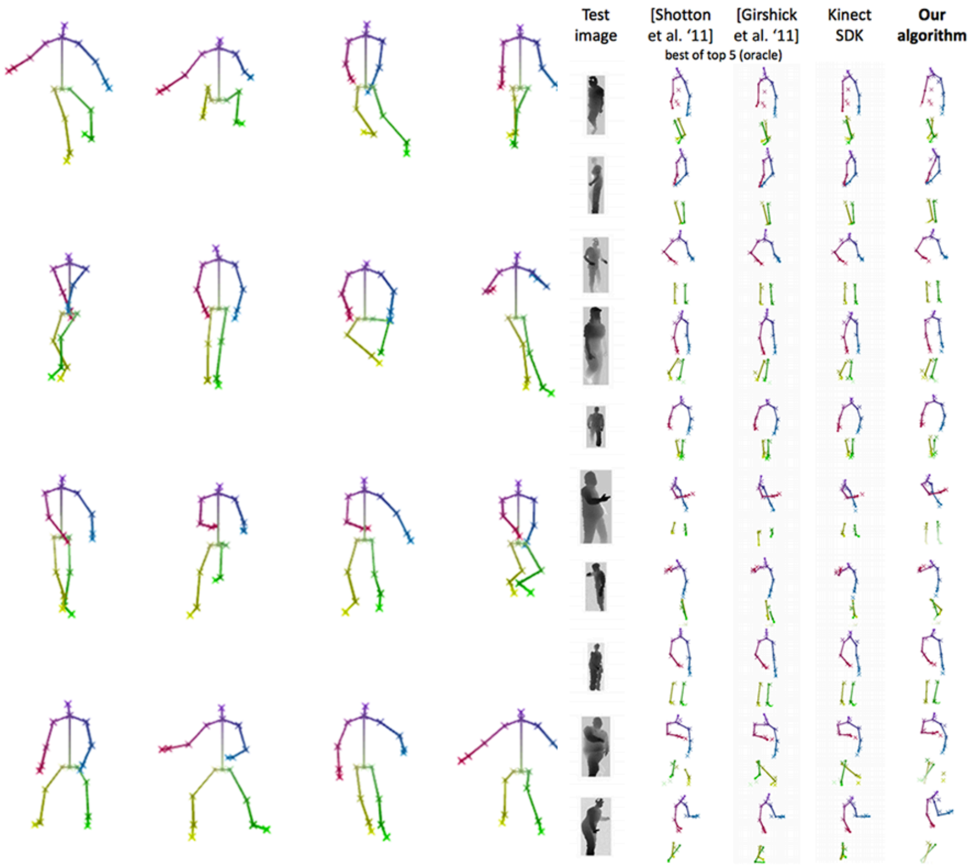


Figure 4.29 Samples and Qualitative comparison with and the Kinect SDK, Taylor *at al.,* 2012.

Microsoft Research was looking for a better way to match input data from the depth sensor with skeletonisation in the future using Kinect's SDK (Shotton *et al.*, 2011; Girshick *et al.*, 2011; Shotton *et al.*, 2012; Taylor *et al.*, 2012) (figure, 4.2.9). These investigations went through several reiterations, one of which used a method of triangulation. In this case, the silhouettes were matched against algorithm-produced skeletal data based on previous iterations of the research. To compare this data with the previous research outcomes, a qualitative comparison process was used, during which four different results were compared according to the visual similarities of the skeletons (right side in figure 4.29). The approach of this aspect of the research provided the basis for the idea of visualising the similarities and differences of expressions by skeletonisation of silhouettes. Notably, since this is one of the features that works with Kinect although, my own approach was different.

The first step was based on triangulation, as specified in section 5.2.5.3, *Triangulation, Quantitative Analysis of Visual Data,* and for each emotion, a frame-by-frame analysis of all video material contained in the PTM database. The application *Movement Collections* was utilized in the process, thus providing the possibility to move quickly back and forth through all the video material at the same time. The application is described in section 4.4.6 *Movement Collections via Korsakow Interactive Database.* During this process, screenshots were taken for each expression characteristic for the performer and emotion, prioritising the postures that were occurring repetitively in the same video. Those were then classified according to the number of postures that reappeared during the 30 seconds of video and arranged in tables (right side in figure 4.30).

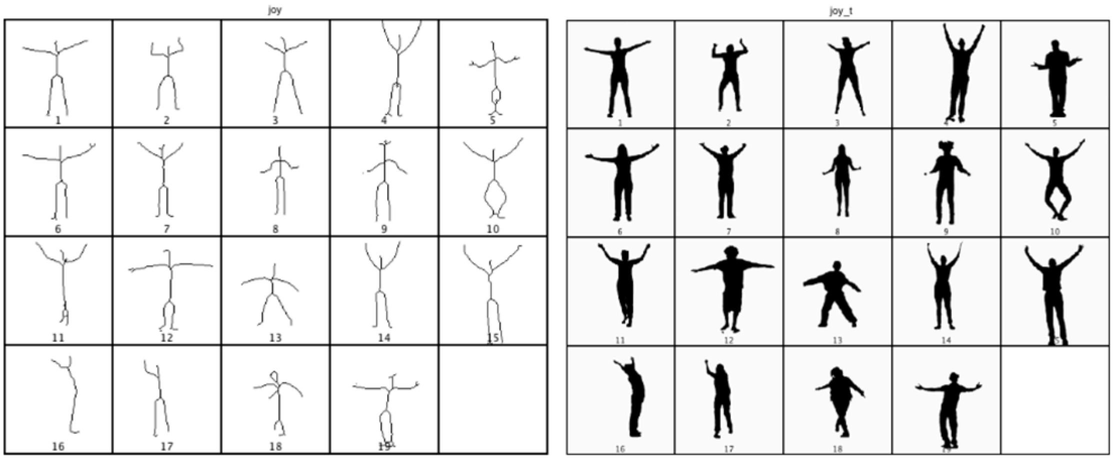


Figure 4.30 Posture diagram with skeletons; Joy, Hrynczenko, 2013.

The posture silhouettes were further processed in ImageJ (Rasband, 1997) software using a skeleton filter, which allows the skeletonisation of silhouettes, a process of shape reduction in a binary image to the skeleton. (left side in figure 4.30).

ImageJ is frequently used for cell analysis where the applied filter was originally developed for analysis of microscopic images. The process of skeletonisation of cells is part of cell studies in cytogenetics laboratories in both biology and medicine. The traditional method known as karyotyping is the final stage of chromosomes' visualisation. The final output of this process is a karyogram —i.e. a diagram of the chromosomes of a cell, organised in homologous pairs and categorised in a numbered series (Turrini, 2013). Karyotyping is a method adopted in my working process, hence chromosomes and skeletonized postures both represent visually dynamic structures. In the context of visual representation in science, Turrini (2013) discusses computer-assisted imaging technologies. He describes the process of image selection for chromosomes, which today is partly automated by a computer system. Since chromosomes need to be reclassified by individually dragging and dropping them by hand to their appropriate place in a karyogram, they are grouped by numbers, letters or both (figure 4.31).

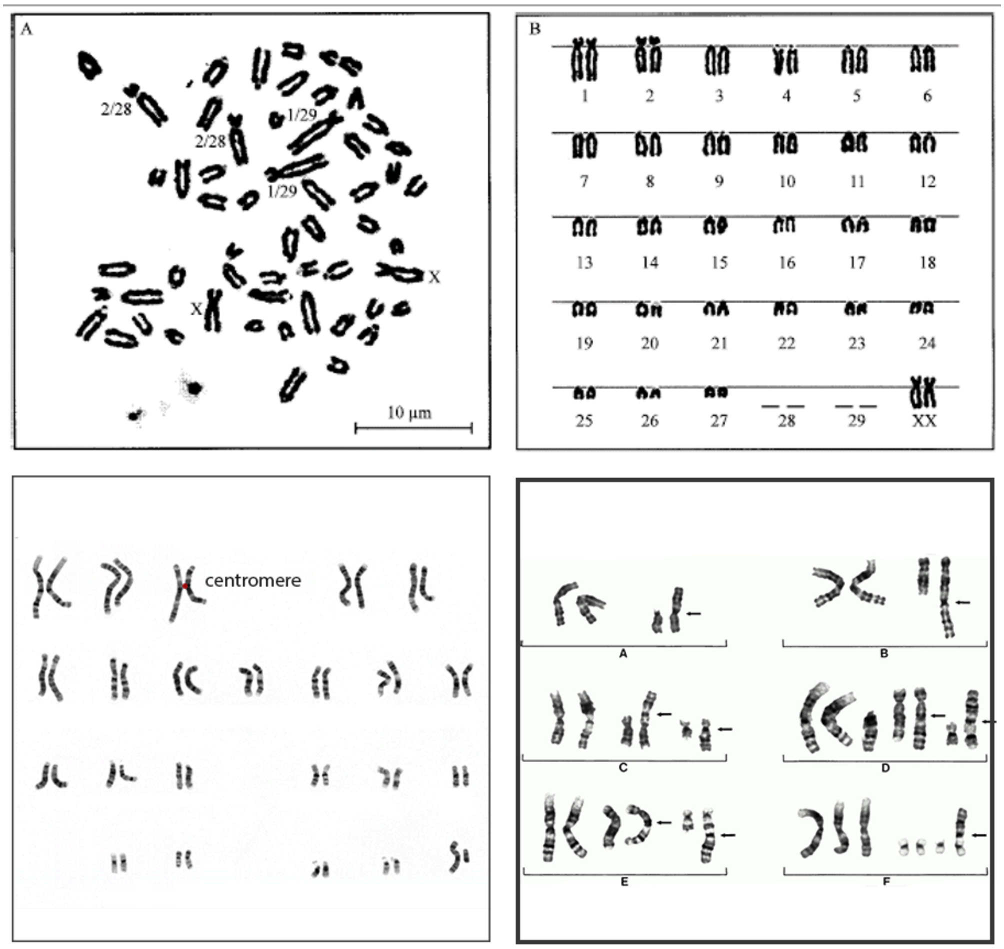


Figure 4.31 Karyotyping, National Human Genome Research Institute, 2012.

> We can see karyotyping as the theoretical, classificatory space of order. Chromosomes are arranged by size in pairs and classified according to their unique distinguishing characteristics, as derived by position of “centromere” (the visible constriction in the centre) and banding pattern; more specifically “homologous” chromosomes are numbered (for humans species from one to twenty-two), and “sexual” chromosomes are identified by the letter X or Y (Fig. 1). (Turrini, 2013).

Karyotyping method offered foundation for the process of posture selection, and letter categorisation. Previous skeletonisation became a basis for visual analysis of posture characteristics. In difference to the karyotyping method, similar postures were classified not in pairs but by using upper case characters that visually correspond to poses in a skeleton karyogram (figure 4.32).

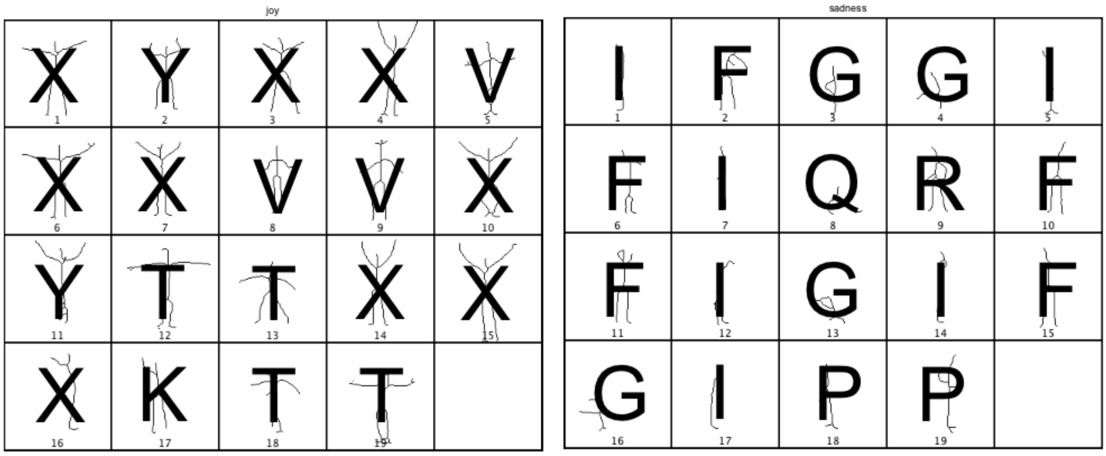


Figure 4.32 Letter labelling; Posture diagram for Joy and Sadness, Hrynczenko, 2013.

Using this approach, these capital letters describe a group of homologous postures also recognised across all four emotions providing a classification for each of the seventeen groups. This tagging system builds the groundwork for the Periodic Table of Movements by establishing the system of correlations among the postures across all four of the emotions investigated.

During the classification process, visual similarities build the ground for group naming by letters. The similarities among the postures are based on parameters such as postures volume, the direction of hands and legs, and shoulders position. The choices of which posture applies to which corresponding letter were subjective, supported by my long visual experience as animator and embodied knowledge of performer and dancer.

4.4.9 Visualisation of Periodic Table of Movements

As input for motion sensing devices becomes relevant in human computer interaction, it is helpful to locate a particular type of expression that could definitely be recognised by computer vision. In the context of game character development and the readability of expressions for movement sensing devices, the objective with the visualisation of posture classification was to outline characteristic postures for each emotion in the data sample, as well as to find correlations in emotional expressions across emotions.

To make this possible, a network analysis method was employed based on a node list table known as a dependencies matrix that provides a relational data file for network visualisation. Network analysis based on Network theory is a mathematical process of breaking down complex data into its smallest elements by representing the problem as a system of lines and nodes in order to reveal the interdependencies and interrelationships among all components (Newman, 2010).

Network theory concerns itself with the study of graphs as a representation of either symmetric relations or, more generally, of asymmetric relations between discrete objects. Applications of network theory include logistical networks, the World Wide Web, Internet, gene regulatory networks, metabolic networks, social networks, epistemological networks, etc. (Roebuck, 2012, p. 246).

The process of creating calculations conceived with the network matrix is presented in two sections: *4.4.8 Shape and Skeletons: Posture Comparison Process* by a brief description, and in a more detailed narrative in 5.2.5 *Network Analysis and Periodic Table of Movements.* The final Periodic Table of Movements structure has crystallised from data collected during the visualisation process, turning from a semantic provocation to an embodied, cognitive and visual structure.

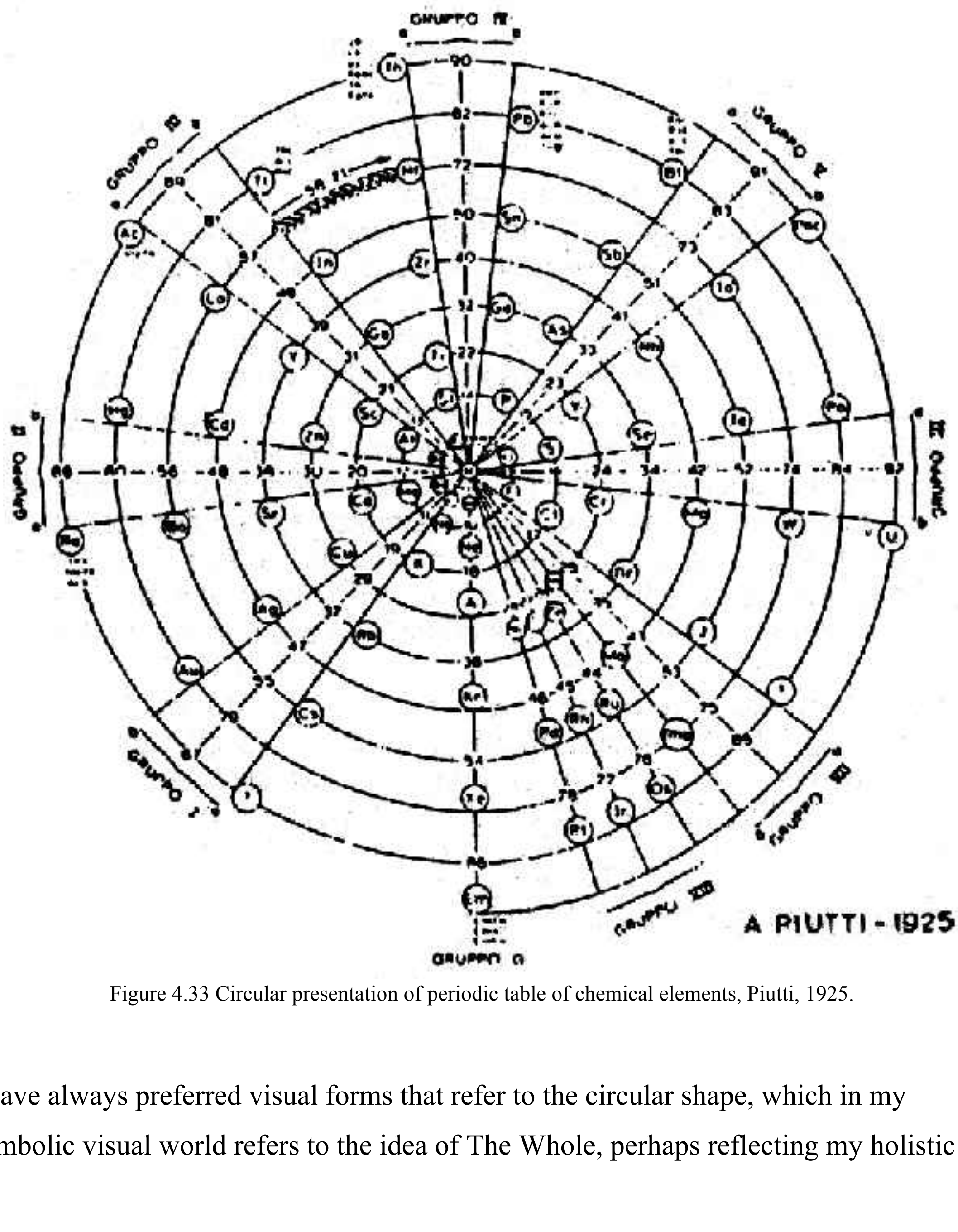


Figure 4.33 Circular presentation of periodic table of chemical elements, Piutti, 1925.

I have always preferred visual forms that refer to the circular shape, which in my symbolic visual world refers to the idea of The Whole, perhaps reflecting my holistic view of the world. Consequently, when looking for the correlation between movement and data, I was inspired by Piutti's (1925) circular representation of the periodic table of chemical elements (figure 4.33). The periodic table of elements becomes a symbol of a visual concept both as a logical system and as an object of previous visual explorations.

The approach explained by Dahlberg (1982) illustrates my own approach to the devices' organizational concept:

> [The periodic table] …has been a conceptual tool which has predicted new elements, predicted unrecognized relationships, served as a corrective device, and fulfilled a unique role as a memory and organization device. The periodic table has contained an innate flexibility, which has prevented it from becoming frozen into a rigid structure. It lends itself to a large variety of forms. Although many of these are unique only as schemes representative of the author's originality, certain forms have unique value in bringing out particular relationships (Ihde, 1969, p. ix).

In pursuing this thought, during my own journeys of discovery, I found the concept of representing the relationship of movement in the form of a PTM table graphic, both highly interesting and challenging. The core idea during this part of my explorations was to visualise the correlations among the key postures in expressive movements in order to highlight these in the context of the four emotions investigated.

Throughout my research and this thesis, my intention has been one of exploring and applying systems to achieve clarity and consistency by using similar visual expressions. The Circos (Krzwinski *et al.*, 2009) data visualisation tool therefore became my primary choice for all data visualisations.

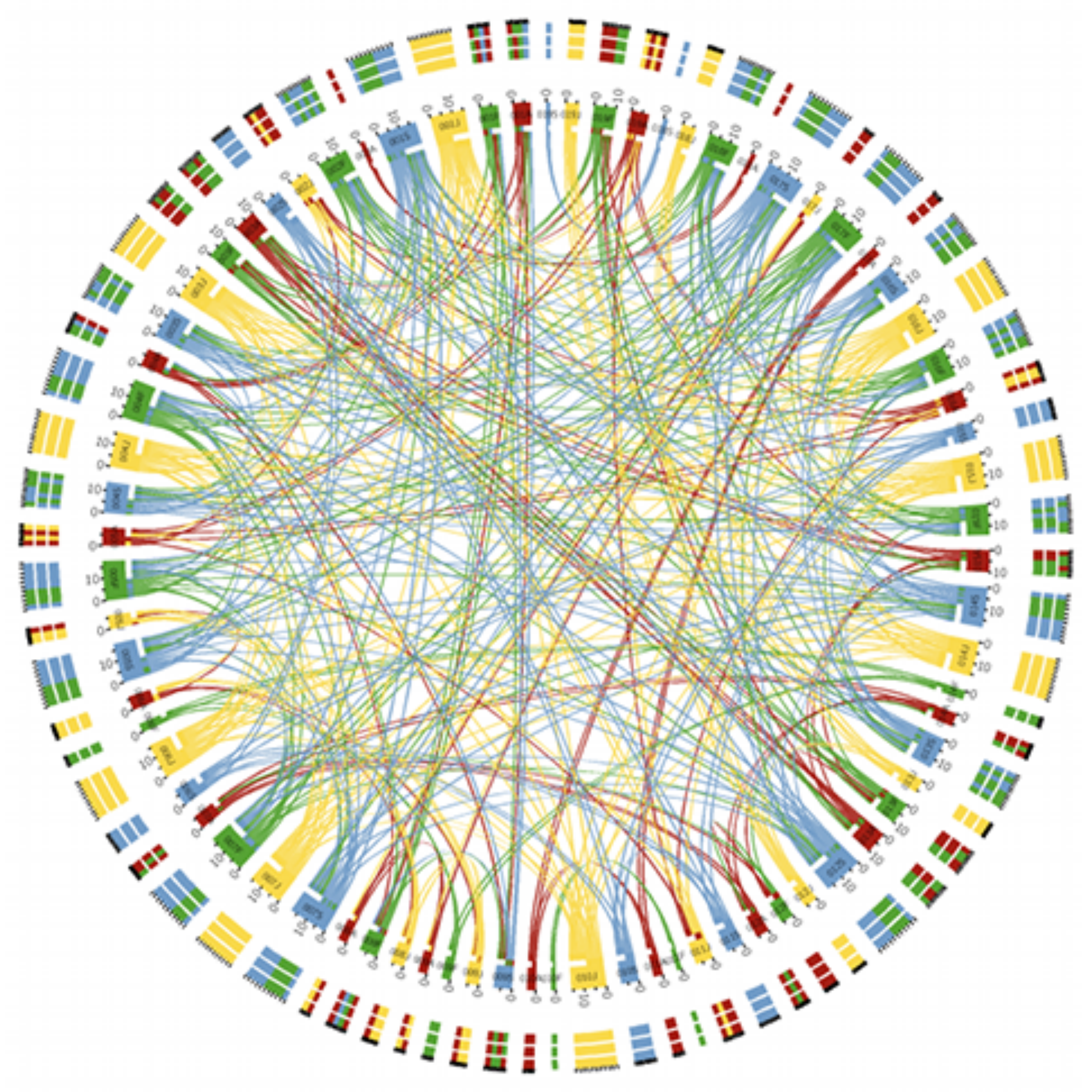


Figure 4.34 Graph of relationships among key postures in Circos, Hrynczenko, 2013.

The first visualisation of network data was processed using Circos (Krzywinski *et al.,* 2009) based on its abilities to produce circular form graphs (figure 4.34). Nevertheless, despite the fact that the visual effect was appealing by emphasising the idea of the 'rhizomatic' (Deleuze and Guattari, 2002) network, and thereby subjectively beautiful, the information contained in the Circos graph was not easy to understand for those uninitiated. In search of a program that could reproduce the relationship among expressions contained in the dependency matrix file in an informative way, my attention has been temporally lost in a plethora of information about visualisations tools.

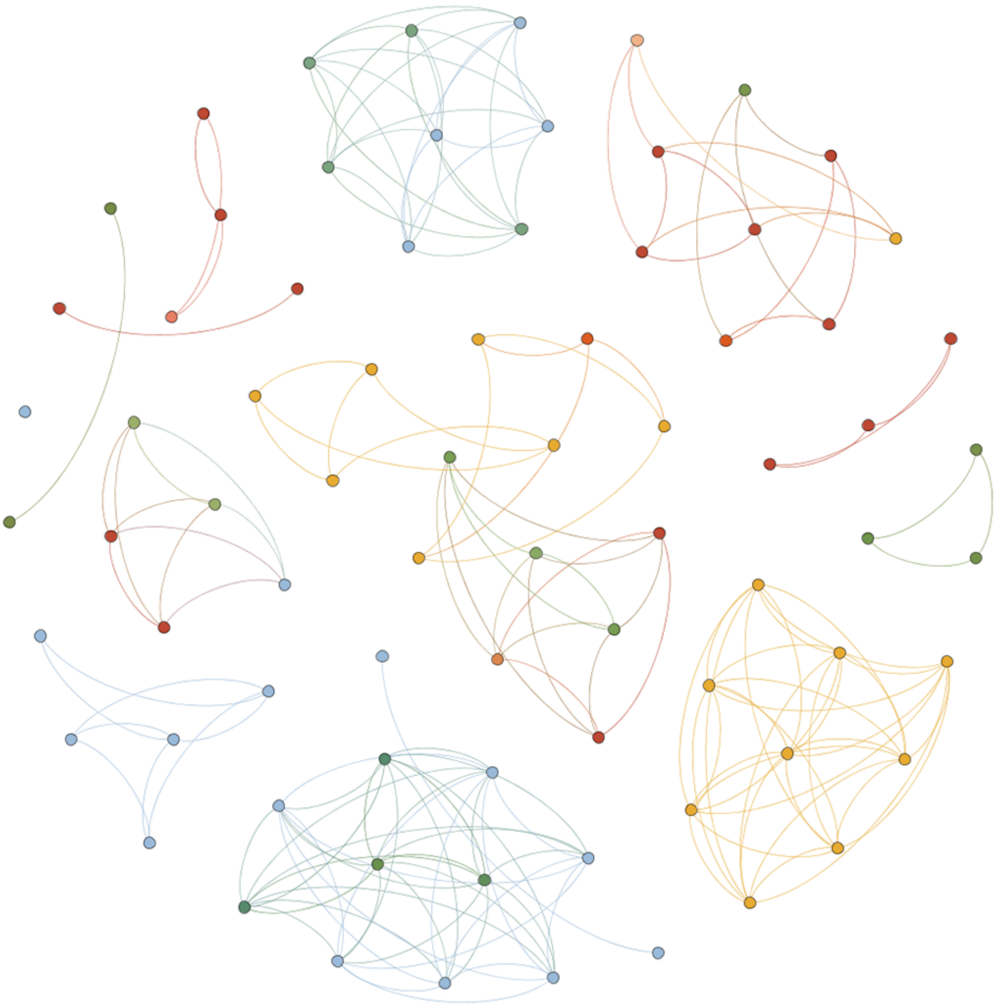


Figure 4.35 Graph of relationships among key postures in Gephi, Hrynczenko, 2013.

During this journey, I have discovered an extensive number of tools for network visualisations, software developed as open source to serve knowledge such as:

- Gephi (Bastian *et al.*, 2009), used in live science and technology
- Cytoskape (Smoot *et al.*, 2011), developed for analyses of biomolecular interaction networks
- yEd (yWorks GmbH, 2007), graph editor, broadly used in live science but previously developed for information technology and engineering
- As an artist, I like these confrontations with new knowledge, as well as the challenges that come with learning the new tools. The experiments with network data started with Gephi (Bastian *et al.*, 2009) and have contributed to a graph where the divergent posture groups become more exposed as shown in figure 4.35.

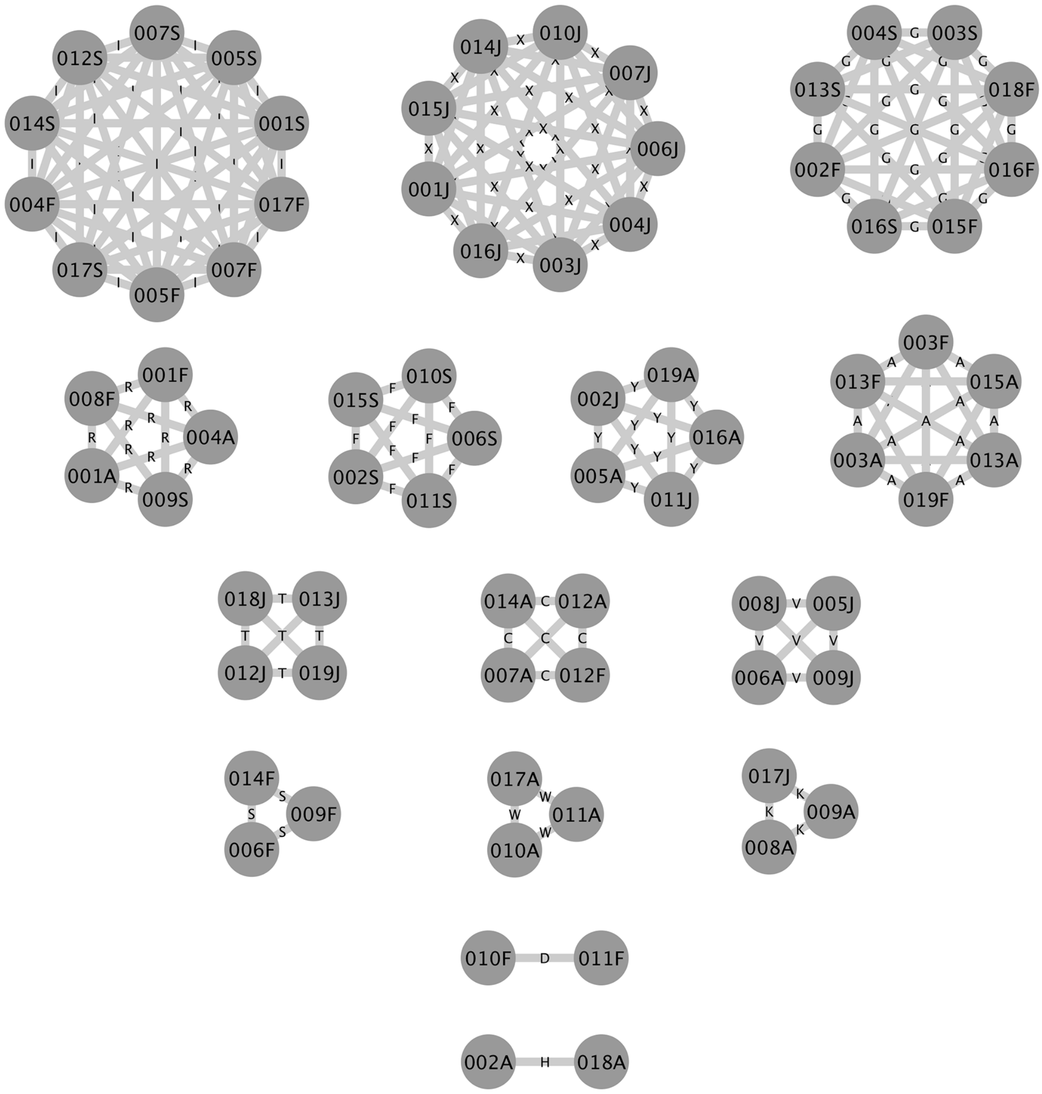


Figure 4.36 Network diagram; Correlations among postures, Hrynczenko, 2013.

Although in a Gephi diagram the complex information about the correlations among emotions was not satisfactory, the structure of the network has contributed to a few new ideas. One of them, employing the molecular metaphor, was to expose each of the posture groups to find a visual form that would illustrate the internal structures for each. The first diagram that follows this idea was created in Cytoscape (Smot *et al.*, 2011), a software for the visualisation of molecular interaction networks as in molecular and systems biology, genomics, and proteomics (Ono, 2013). Figure 4.36 is a diagram of posture relationships divided into networks of the specific postures selected from each video clip.

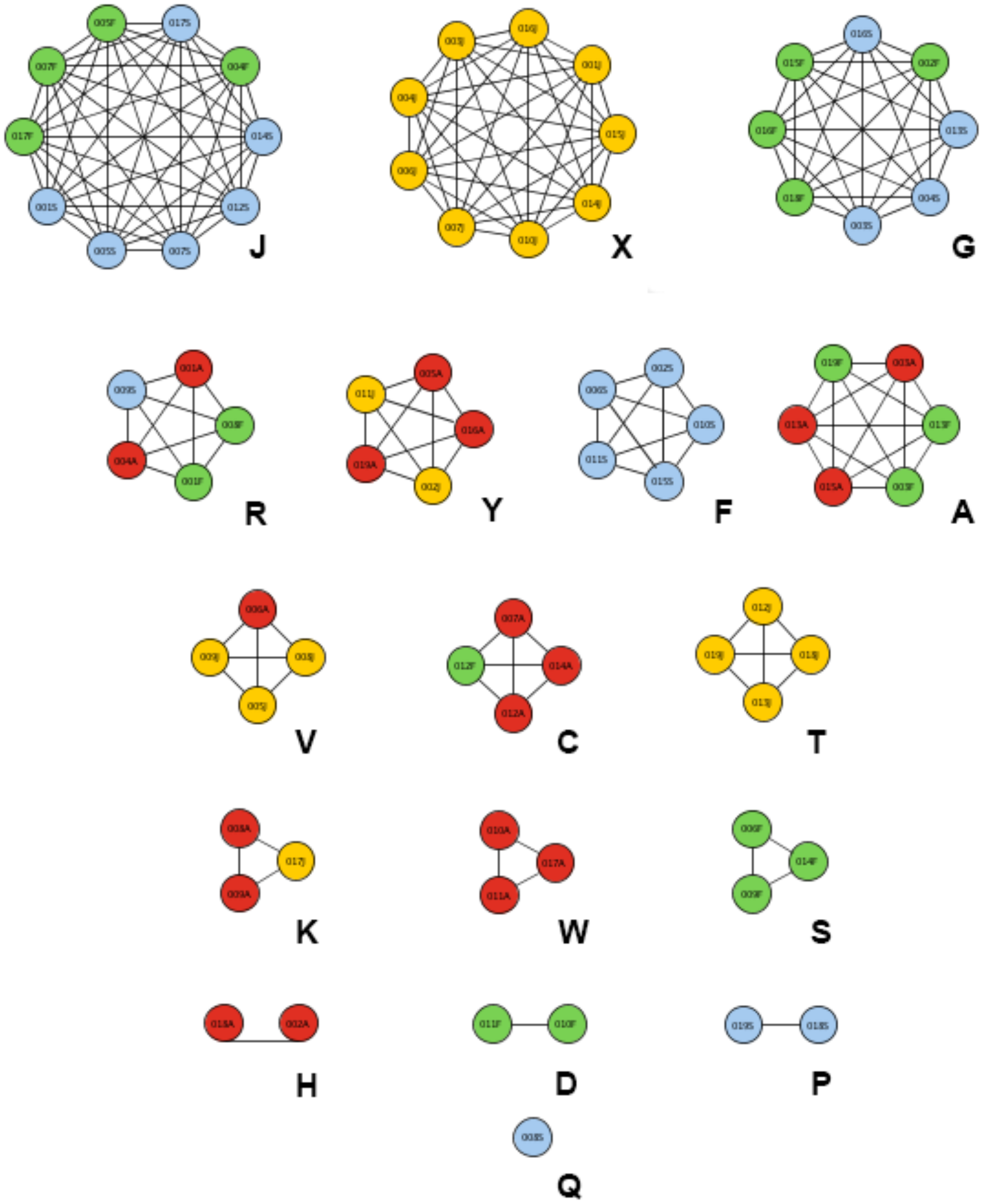


Figure 4.37 Network diagram in yEd; Correlations among postures with emotions in colour, Hrynczenko, 2013.

The numbers of the network nodes represent the source video number, where the capital letters on the connection lines express the characteristic posture as previously described in section 4.4.8 *Shape and Skeletons: Posture Comparison Process*. The second graph (figure 4.37) is an effect of colour implementation, which I found in the yEd network visualisation tool. The incorporated colour information provided a relational overview of four emotions: anger, fear, joy and sadness.

The yEd diagram provided information for emotional expressions that show similarities in expressions across all four emotions. Following the metaphor of the Periodic Table of Elements, I have decided to explore emotional expressions on an “atomic” level by using postures as key frames of movement in the search for correlations in a symmetry system.

The second iteration of the design process is aimed at incorporation of all groups in the circular model that would emphasise one example from each group by representing the generic key postures. Given that the key postures are only possible to describe by the visual expressions, silhouettes play a central role in the design of the final table. The intention in this approach was to provide a simple and pedagogic self-explanatory tool for generic key postures and to showcase the possible errors of interpretation that could arise when similar expression occur for several different emotions. This condition is particularly important in the context of optical, motion recognition devices, and plays a central role in the final design of the Periodic Table of Movements.

The solution to the previously described requirements is achieved with yEd's ability to render network data in several layouts; consequently, with some adjustments of the radial layout, the data could be rendered into a circular graph allowing an exposition of a zoomed-in version of one element in the group. In order to apply the silhouettes as self-contained information to each of the graph's nodes, the graph was exported to Photoshop where thumbnails of the silhouettes, contained in the database, were applied according to specific control numbers (figure 4.38).

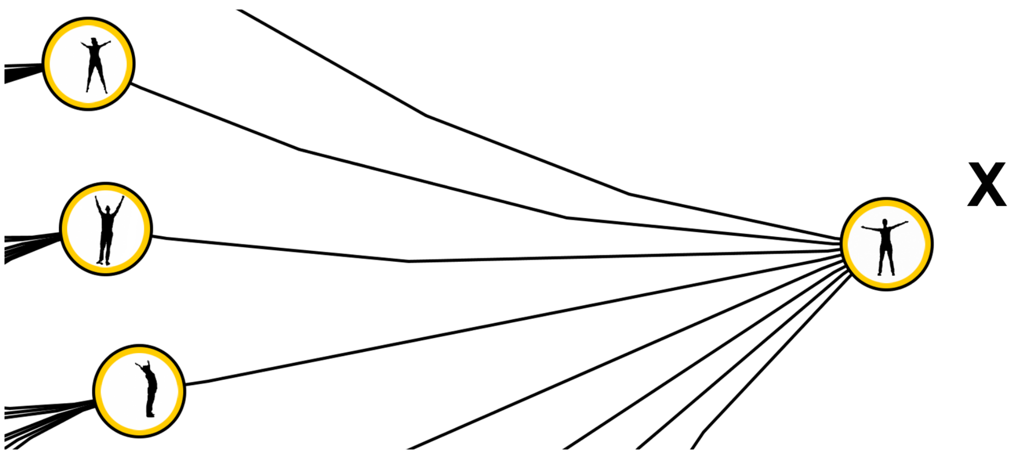


Figure 4.38 Graph of relationships among key postures in Gephi, Hrynczenko, 2013.

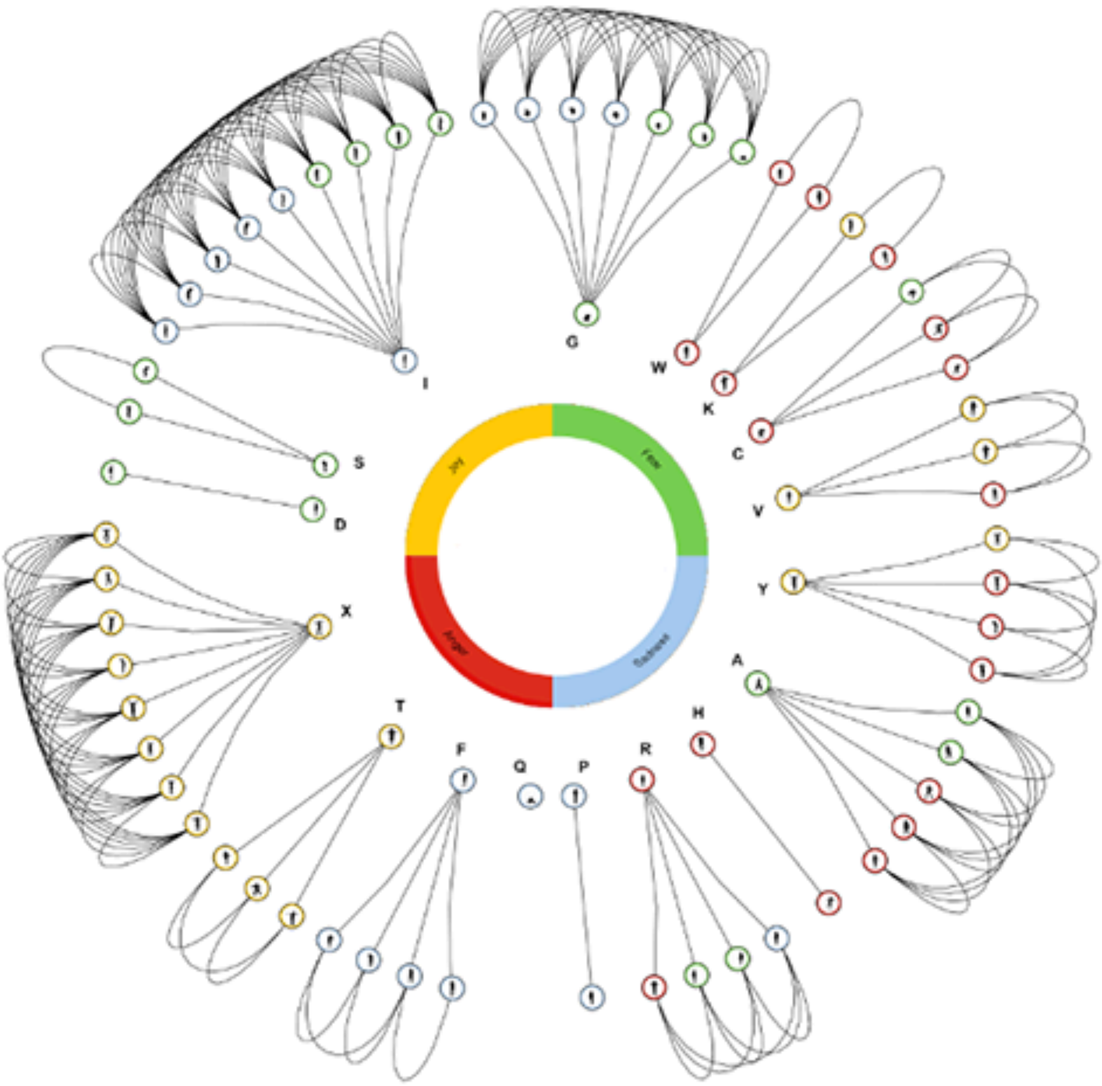


Figure 4.39 Periodic Table of Movements Graph in 1:4 scale. Hrynczenko, 2013.

At the end of the design process, an explanatory colour key was added as a reference to circular colour tags on each of the nodes.

The first example of the Periodic Table of Movements (PTM) was produced with consideration for good printing quality, therefore with a large pixel value and printing size to distinguish the specific shape of each silhouette and enhance its visibility in the final graph. A 1:4 scaled version of the graph is shown in figure 4.39 and Appendix L also provides an example of the PTM in a scale of 1:3

4.4.10 Summary

Several practical reasons and other circumstances directed this research toward the field of infographics and data visualisation. One of the reasons was concerned with the need to provide an overview of compact information and to make the PTM concept understandable for future users, contributors and collaborators. As a solution, infographics were produced where maps, colours and patterns were used to create a conceptual platform for discussion and scenario testing. Another reason was the instrumentality of infographics and data visualisation as an exploration tool, and the necessity to compile the visual and statistical data in order to identify similarities in emotional expressions as well as to identify and compare movement characteristics of each emotion.

The visual artefacts linked the numerical data (statistics and measurements) with subjective values and choices. Consequently, visualisation of both qualitative and quantitative data was carried out leading to valuable conclusions for the research, and essential to provide conclusive evidence to address the research questions. I have employed creative analysis based both on quantitative data and on visual transcriptions of this evidence, extending the database with the additional information accessible for future users.

This is where sophisticated visualisations come into play becoming part of a storytelling process as an attempt to document and expose correlations, patterns, otherwise invisible features and irregularities hidden behind the numbers. At the same time, the process of encoding the emotions as expressive movements in space and time, in their physical, scientific and imaginary dimensions, metaphorically becomes a laboratory dissection. In this process, the visual essence of emotions was divided into divergent data objects, such as; plots, thumbnails, skeletons, letter signifiers, kinespheres, networks and finally the same expressions were condensed as individual postures manifested as a part of the graphs. This approach became more of a symbolic confrontation than the previously described, assigned goals of a research journey. Following this detour, the symbolic value of diagrams reflects the more intuitively assigned name for this research project; A Periodic Table of Movements. Nevertheless, as the research continued it became a simulation of scientific methods as a developent of Deleuze's and Guattari's, (2004) ‘line of becoming’, reflecting an intentional yet paradoxical situation. In this context, the form of the diagram is symbolic; a result of generative processes, an abstract of emotions away from their physical origin hiding a tacit knowledge contained in the human body.

The visual data was obtained through several iterations; firstly, the recorded video material was transformed to silhouettes in motion, and then in the next step these were adapted to the interactive movement collections using the Korsakow tool (Thalhofer, 2007). During the triangulation process, in which timeline charts, survey data graphs and movement analysis graphs were compared, the characteristic postures for each of the emotions emerged providing a set of silhouettes. This convergence provided a starting point for the posture comparison process, based on visual calculations of similarities in skeleton postures. Accordingly, using the quantitative data received from the skeleton similarity recognition method, the network data was established, a process that is described in section *5.2.4.7 Spatial and Visual Data Analysis* and as illustrated in figure 4.40. The visualisation of the Periodic Table of Movements is based on the steps described above concluding with two graphs; One, that represents the correlation of expressive postures for each group, and the other representing all groups as silhouettes in a circular form, illustrated previously, a design feature intended to visually augment the generic postures and their connections.

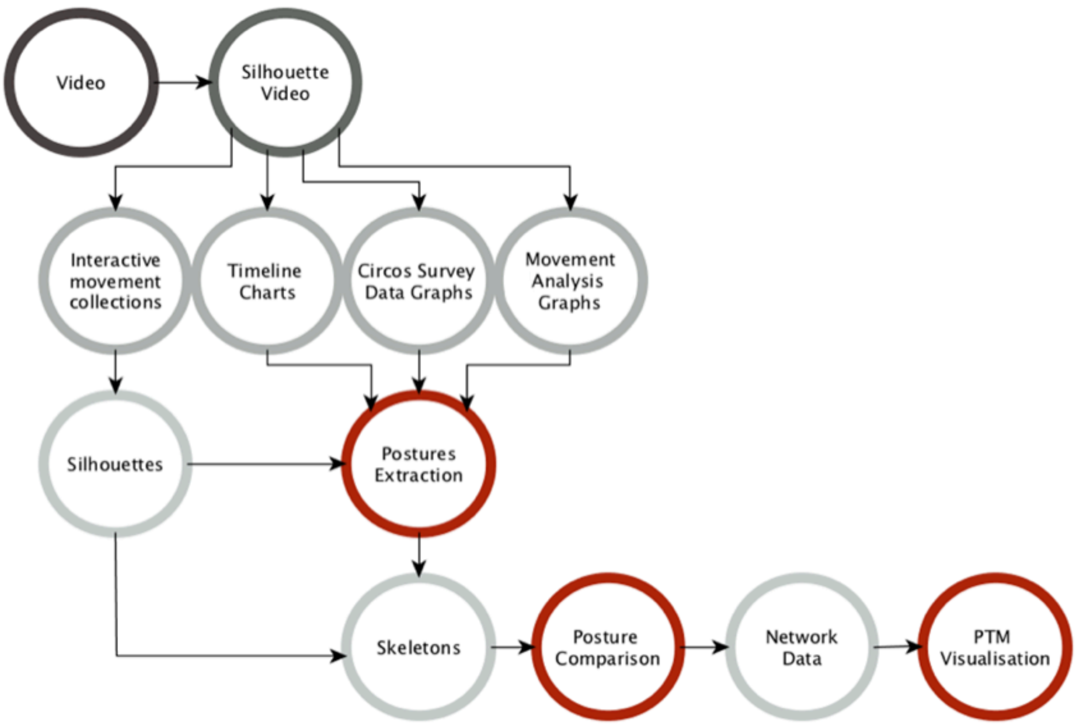


Figure 4.40 Diagram of the visualisation process, Hrynczenko, 2014.

4.5 PTM: Web Based Database

Increased Internet bandwidth has opened up new possibilities for digital archiving, allowing much larger volumes of data to be collected on servers or in the "cloud" and quickly distributed. Today, media heavy content such as video and film is available to the public through the Internet. There are two reasons why the database of expressive gesture and whole-body movement become central for this research. As the contextual research indicates, there is extensive previous and ongoing research on how human emotions are represented in facial expressions but proportionally a very small amount of research that considers whole-body expressive movements and gestures. In proportion to facial recognition there is only a very small amount of research available on whole-body expressive gestures in relation to virtual worlds and games. The possibility to collect data and documentation on whole-body emotional expressions in an online database could provide a basis for future research in the area of human motion, and emotion in relation to our real and digital lives, further suggesting potential use in HCI, game design, character animation, anthropology, social sciences, and many more discipline areas.

The second reason, subjective in nature, is the creative challenge from the point of view of a performance artist, gamer or designer based on the ontological nature of the database as an archive, allowing an approach comparable to a librarian in terms of categories of the physical manifestations of emotion.

As an effect, a substantial portion of the research was devoted to developing a library of expressive movement and gesture, all collected and structured in the framework of an online database. At the same time, this approach has extended my knowledge of information structures, representation and presentation as well as data validation.

This next section describes the database construction and working process divided into modules dictated by the database construction. The section concludes with a summary followed by a discussion on possible additions to the library, a future possible extension and various applications based on body movement and gesture using input from Kinect (Microsoft, 2010).

4.5.1 Design Process and Prototyping

The initial conceptualisation phase was mainly based on concept creation and the visualisation of ideas via sketches. In addition to the video material, the first problem identified was how to structure the database in order to provide extensible content in order to create multiple representations of embodied emotion expressions. Secondly, how the content should be presented in order to generate expanded information about whole-body movement.

In the second phase of the conceptual design, the starting point builds on the question; what model of information should be used for user activities and how should it be implemented? This more complicated part demanded explicit details of complex systems, therefore, in this phase I collaborated with a database programmer, Blazej Pindelski, University of Dundee.

The primary issues investigated are based on representation of expressive movement by a blended approach using different media; numerical data, video, graphics, graphs and charts. The secondary issues are the interrelationships of the data collection and their logical and visual structure. In order to manage the analysis challenge the large volume of information was structured using taxonomies, wireframes, diagrams, labels and specification notes when defining the 'information ecosystem' (Davenport & Prusak 1997 p. 288), where the information architecture was a first part of the design.

Amdahl *et al.,* 1964 (via Resmini & Rosati 2012 p. 33) defines information architecture as 'the conceptual structure and functional behaviour, distinguishing the organization of data flows and controls, logical design, and physical implementation'. In order to distinguish the information ecosystem of the PTM database three fundamental sectors of the design are presented below:

- the information architecture; the structure of the information that could easily be retrieved when searched (Rosenfeld and Morville, 2006; Morville, 2012).
- information representation; describes usability and interface design through which it is possible to communicate information (Chu, 2010; Khan, 2012).
- information visualisation; is content presentation taking into account information aesthetics, complexity, and the multiple ways and purposes according to which information can be used (Banissi *et al*., 2014; Tufte, 1983).

In the context of the PTM, the structure is defined as a result of summarised information gained during a funded summer research school organised by the Arts and Humanities Research Council (AHRC) and Joint Information Systems Committee (JISC) and Curating Artistic Research Output (CAiRO, 2011) with a focus on "Documenting and Managing Art as Research" at the University of Bristol, Department of Drama (27-30 June, 2011).

Producing and archiving documentary material raised some practical questions regarding material preservation and information structures, highlighting the need for further information in order to generate a functional design of the PTM database. The summer research school contributed to this research with new knowledge providing structural overview on information systems, methods and tools for 'data curation' (Clarke and Warren, 2009).

The workshop focused on questions such as: 'What form might documentation take: multimedia, text or a blended approach? What is expected by research funders such as the AHRC? Can we maximise the impact of our research by ensuring adequate documentation survives and is used?' (CAiRO, 2011). As a design parameter, the database focused on media such as video, graphics and visualisations of data thus extending the primary objective where only video information was used to present expressive movement.

The evaluation phase focused on usability issues and logical representation of the data and visualisations, especially in connection to the videos. Additional implementation of the Korsakow (Thalhofer, 2007) nonlinear database was an alternative solution to provide an interactive and user-friendly overview of all expressions and an additional, analytic tool with playful features.

4.5.2 Information Architecture of the Database

During the structural design of the PTM, information was classified in a coherent composition such as navigation, data classification and labelling structures. The construction was created during the iterative process based on feedback from my software collaborator and database programmer. The model was finalised in the form of a content diagram and interface schematic.

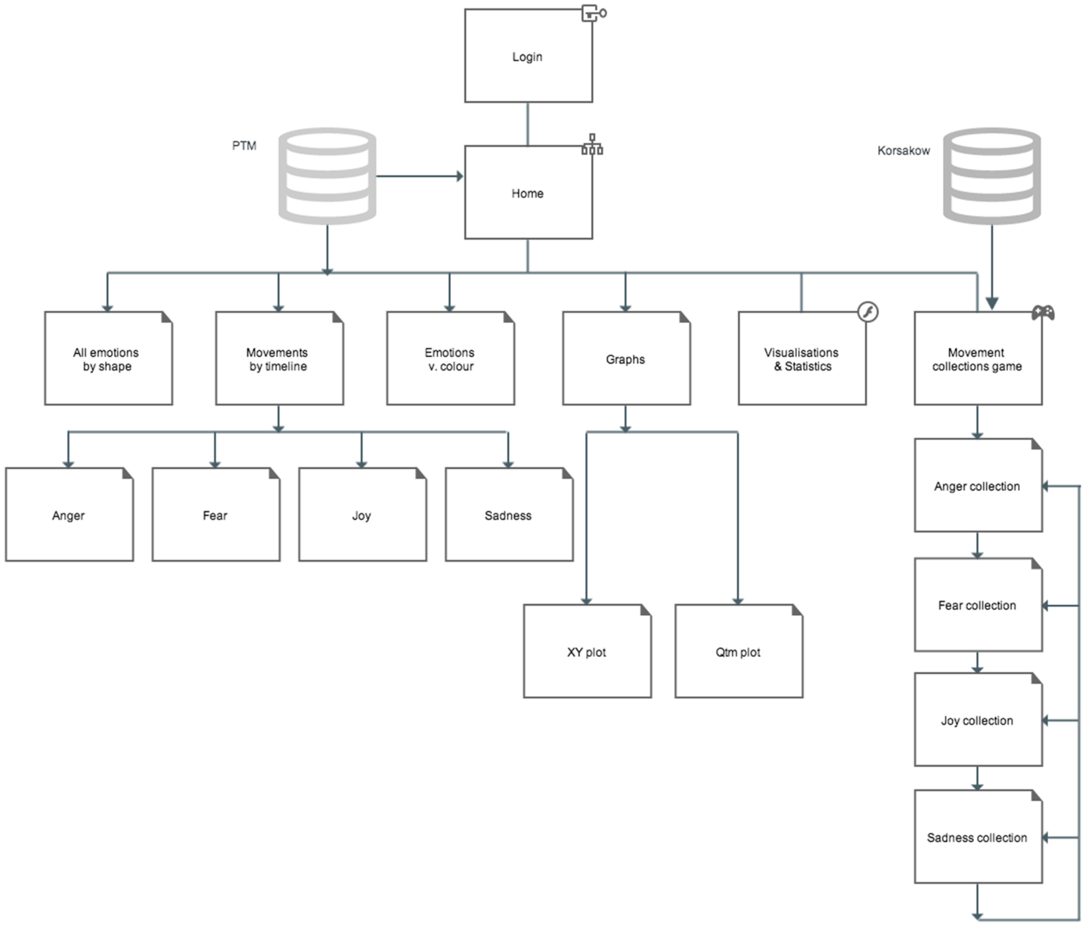


Figure 4.41 Flowchart; Database of Expressive Movement, Hrynczenko, 2010.

For this purpose a structure chart (figure 4.41) and specification sheet were used together with wireframes designed in the Mocap design program Balsamiq Mocaps (Balsamiq Studios, 2008) as a communication platform with the programmer. This organisation of information builds the basis for further development both for the database structure and the interface design.

The PTM database is presented to the user in the form of a web application outlined in figure 4.42. At the data access layer, a relational database management system (RDBMS) MySQL (MySQL AB, 1995) is responsible for storing the metadata associated with images and measurements. The image data are stored on the file system of the server hosting the web application. On the application layer, a server-side scripting language called PHP (Lerdorf, 1995). is responsible for dynamically generating the HTML content rendered and displayed in the browser. Additionally, PHP also queries the database for data. The language also provides end points (services) for client-side (browser) scripting languages, such as JavaScript, for accessing data.

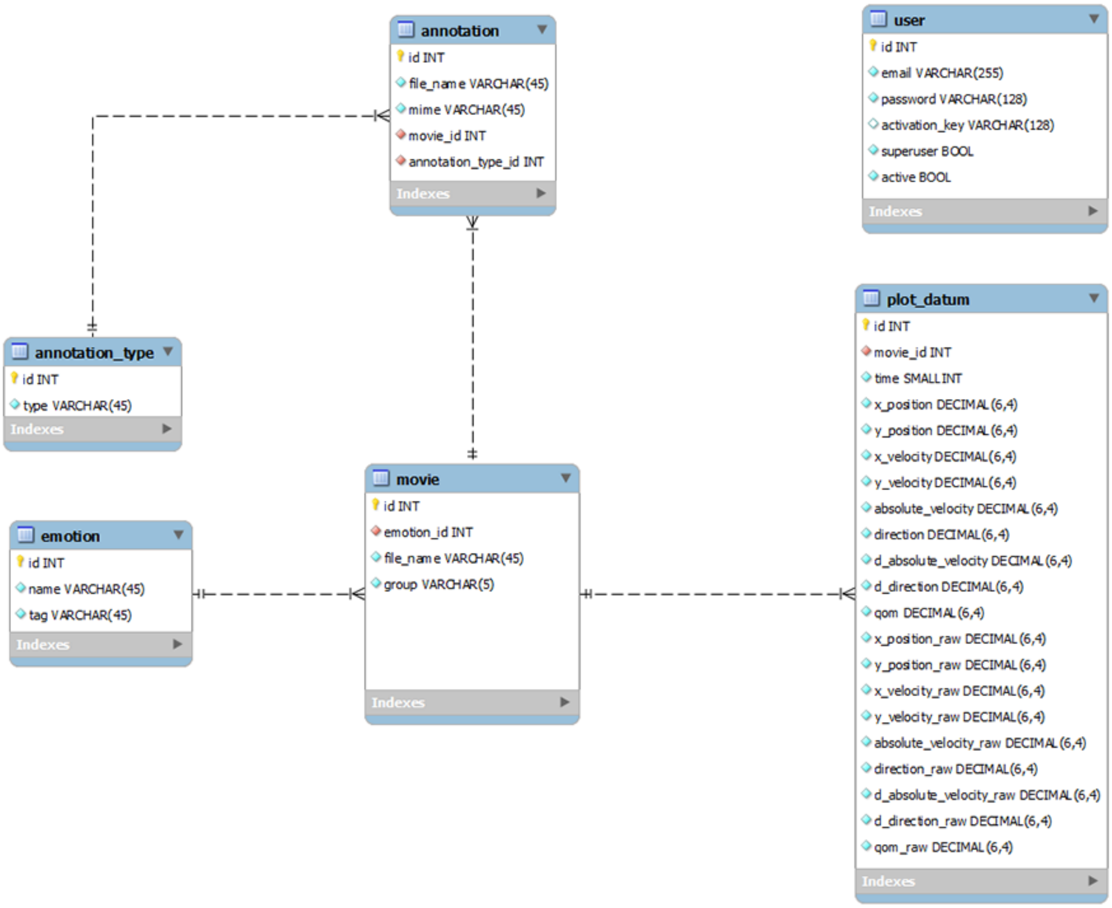


Figure 4.42 Database management system, Pindelski, 2012.

The client-side scripting language JavaScript is employed to change the content of the web application without making unnecessary calls to the server or reloading the page displayed in the browser.

The implemented database scheme balances the use of deployment with the relational system needed to hold information about the data used by the web application. A single stand-alone 'User' table does not refer to any other tables and the only information that is stored are user credentials (user name, password, etc.). The user's password is encrypted and stored according to recognised security principles (The International Information Security Foundation via Poore, 1999).

The ontology of the system is built with regards to metadata about movies and images where a set of relationships has been proposed. The central table that acts as a starting point for database queries is the 'Movie' table. It stores information about the movie name, to which group the movie belongs and what emotion is represented in the movie. A set of emotions is stored in the dictionary table called 'Emotion'. The movie also has a relationship to the 'Plot datum' table that holds numerical results of each movie frame

analysis (X and Y position and velocity of pixels etc.).
Each movie can be annotated with an extra file. Information about those files is stored in the 'Annotation' table, which acts as a link between the tables: 'Movie' and 'Annotation type'. The latter table is also a dictionary table describing the possible types of relationships available in the database.

4.5.3 PTM Information Representation

The database content is conceptually specified as an ontology model in the form of a graph wherein each mode represents a searchable category. The graph represents the structure of the database indexed as a website's navigation nodes where categories are listed as hyperlinks. Emotional expressions are labelled with colour values allowing information retrieval also via colours. In order to provide summarised information of video content, timeline visuals and video collections are categorised according to emotions summarised in the video content. The analysis of the numerical data is presented in data visualisations such as plots, i.e. diagrams of kinematic data previously described in section 4.4.4 Visualisation of Kinematic Data i.e. Emotions to Diagrams . Instead of descriptive models of metadata, summarisation via charts is used by dividing video content into smaller segments creating entities that are more meaningful.

The chronographic charts, described in section 4.4.5, provide an overview of the video content that can be viewed as groups of charts according to each emotional function as well as condensed Walk Cycles with emphasis on key postures. In this module, each chart is linked to the original video and can be used as a visual search method. Information retrieval is possible via search categories i.e. by emotion, colour or video filename as well as via a visual collection of thumbnails. The previously described Collections Quiz displays all video clips in a small format on one page according to each emotion. This extended part of the PTM database provides quick video content retrieval with a user-friendly and intuitive interface (figure 4.43).

The colour system based on colour classifications of emotions (Plutchik, 2001) and research by O'Brien (2007) was applied as a labelling system for each of the emotions and used as the navigation system and visual characteristics for each of the database pages (figure 4.44). The background to colour choice is explained in depth in section 4.4.2 *Colour Choice and Explorations*.

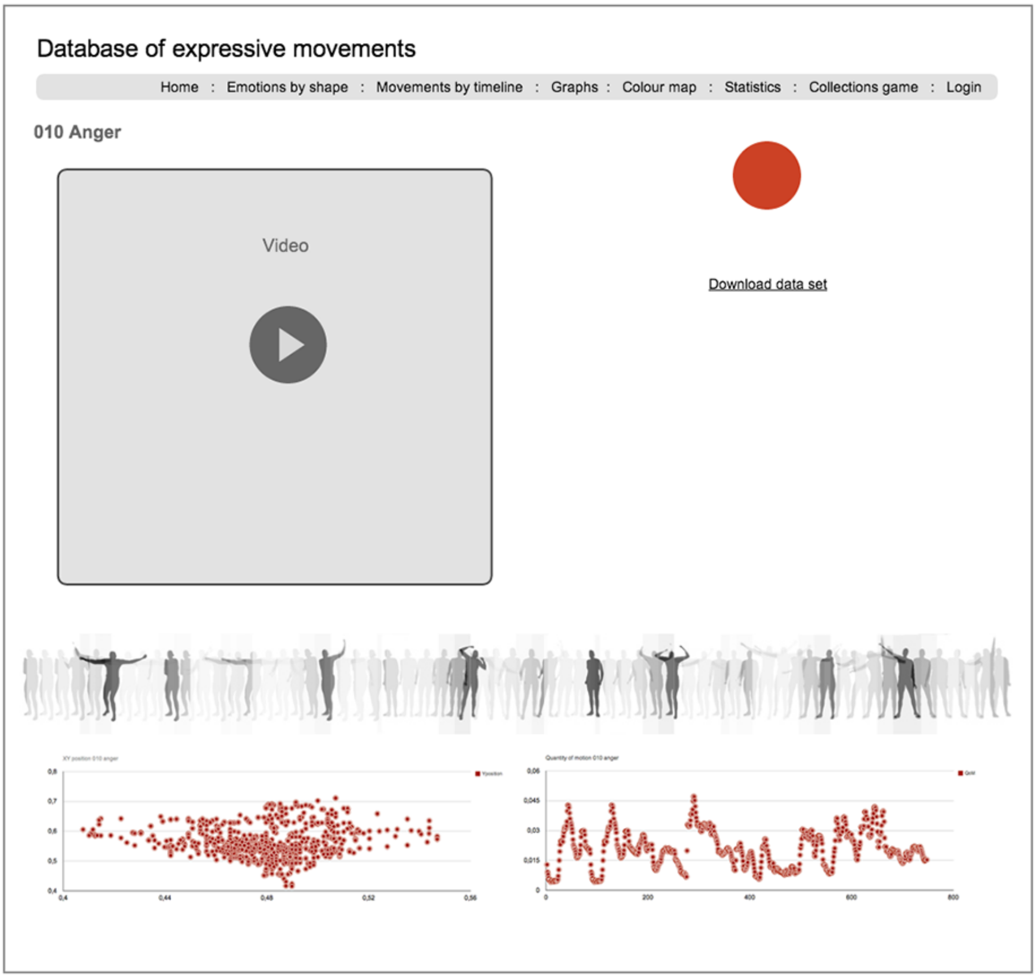


Figure 4.43 Screenshot, PTM database; Wireframe of video page, Hrynczenko, 2013.

Figure 4.44 Colour as navigation in the database, 2012, Hrynczenko.

Testing was an iterative process connected to interface design and adjustments of the database as new content elements were added during the development process as additional features; an effect of the parallel, ongoing process of movement analysis and visualisation. The PTM interface structure supports the visual characteristics for each emotion based on movement graphs thus providing the possibility to compare these with the particular style of performers movement visualised in the chronophotographic timeline charts. This system supports a triangulation method built in the interface of the PTM allowing comparative visual analysis, a feature that helps to estimate the characteristic movement patterns for each video clip.

4.5.4 PTM, Information Visualisation

Visual abstraction and information visualisation are a part of the structural design of the PTM database widely described in section 4.4 *Movement Visualisations Process and Data Aesthetics*. In this section, the correlation to the database structure and information representation is explained. The information contained in the PTM database is mainly based on visual material, however the movement data analysis is based on extensive quantitative information translated from non-visual data into visual clues. The visual analysis contributes to a better understanding of movement patterns in relation to the video data, expanding the information with the movement intensity and movements x and y coordinates.

To better present an overview of all emotions, additional web pages were designed using the Korsakow System (Thalhofer, 2007). This way each of the video clips are also presented in a scaled down format and as part of the video collection of each of the four emotions chosen for the study. In addition, the user can view each video as a preview using a 'mouse-over' function. An overview of the anger collection is presented in scetion 4.4.6 *Movement Collections via Korsakow Interactive Database*. The implementation of the Korsakow system (Thalhofer, 2007) provided an option for movement analysis used during the triangulation described in section 5.2.4.10 *Triangulation, Quantitative Analysis of Visual Data.*

In the Database section, *Visualisations and Statistics* provide validation of documented expressions based on the results from an online survey measuring the recognition factor of emotions expressed on each video. The process and results of this evaluation are presented in section 5.2.4 *Emotions as Silhouettes in Motion, The Online Survey.* The results, based on recognition points, were converted to circular graphs described previously in section 4.4.3 *Visual Interpretation of Survey Data*.

The challenge in this part of the study was to understand statistics as a tool for visual explorations. Statistics are a powerful tool essential for the future collection, analysis, interpretation and presentation of data. Whereas the visual presentation of data in the form of diagrams and charts provides a powerful tool for communication. The knowledge gained from basic training in statistics enabled visualisations to be created from large quantities of raw data. The graphs produced provide database users with quick information on how many recognition points the expressions in each video had received. I found this an interesting feature that offers another dimension of the viewer's perspective, also stimulating future research on correlations between perception of emotions and the physical body, posture and movement. For this purpose an interactive applet was produced in Adobe Flash, software for animation and interactions, where recognition points in the form of circular graphs were brought together.

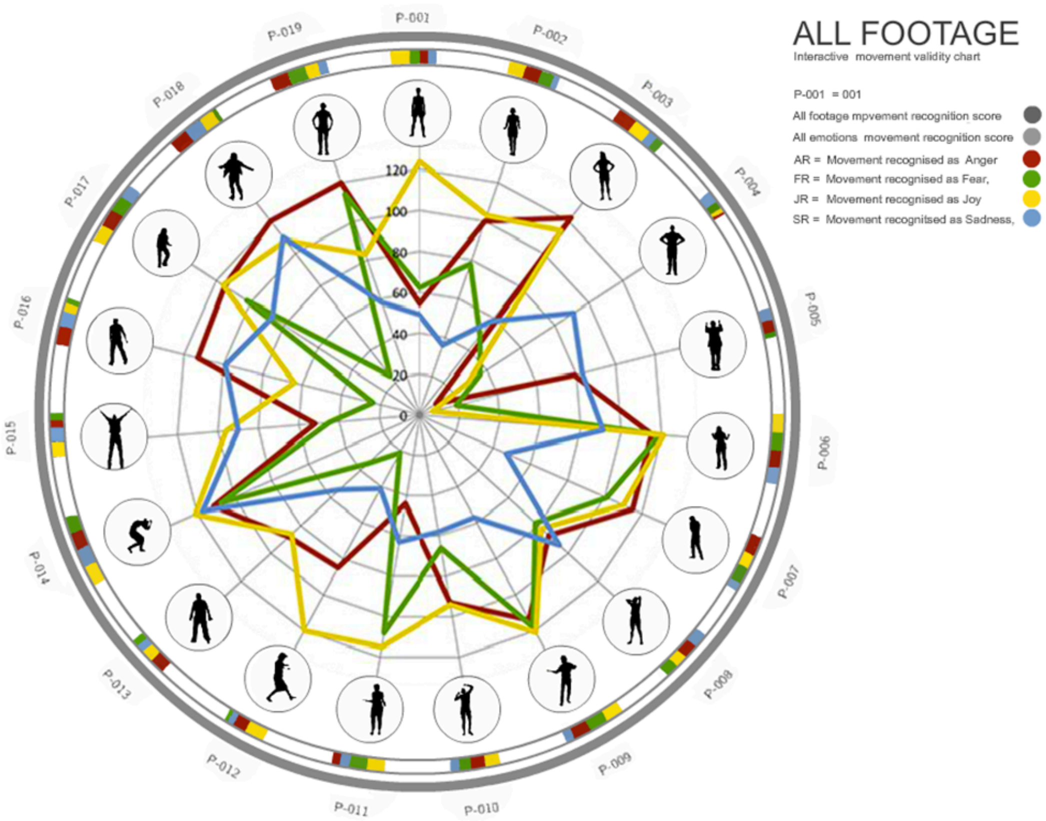


Figure 4.45 Evaluation results for all emotions and footage, Hrynczenko, 2013.

The purpose of this feature is to provide an overview of the relationship between performers' expressions for each emotion as well as to visualise the total scores of all expressions. The applet presents an overview of all recognition points of expressed emotions based on a radar chart connecting it with performer's silhouettes, and a search option to see the scores of each emotion separately. An example is presented in a graph of all video footage recognition points in figure 4.45.

The explanatory colour key feature serves as a search menu providing a quick overview of all graphs. A magnification of the original image in figure 4.45 is shown in figure 4.46. The colour tagging system in all graphs is based on Plutchik's (1980) colour wheel of emotions.

Figure 4.46 Magnification of search menu, Hrynczenko, 2012.

Using this menu leads to visualisations of each of the four emotions: anger, fear, joy and sadness. The sample graph in figure 4.47 illustrates recognition scores for the emotion anger where expressions of anger were evaluated.

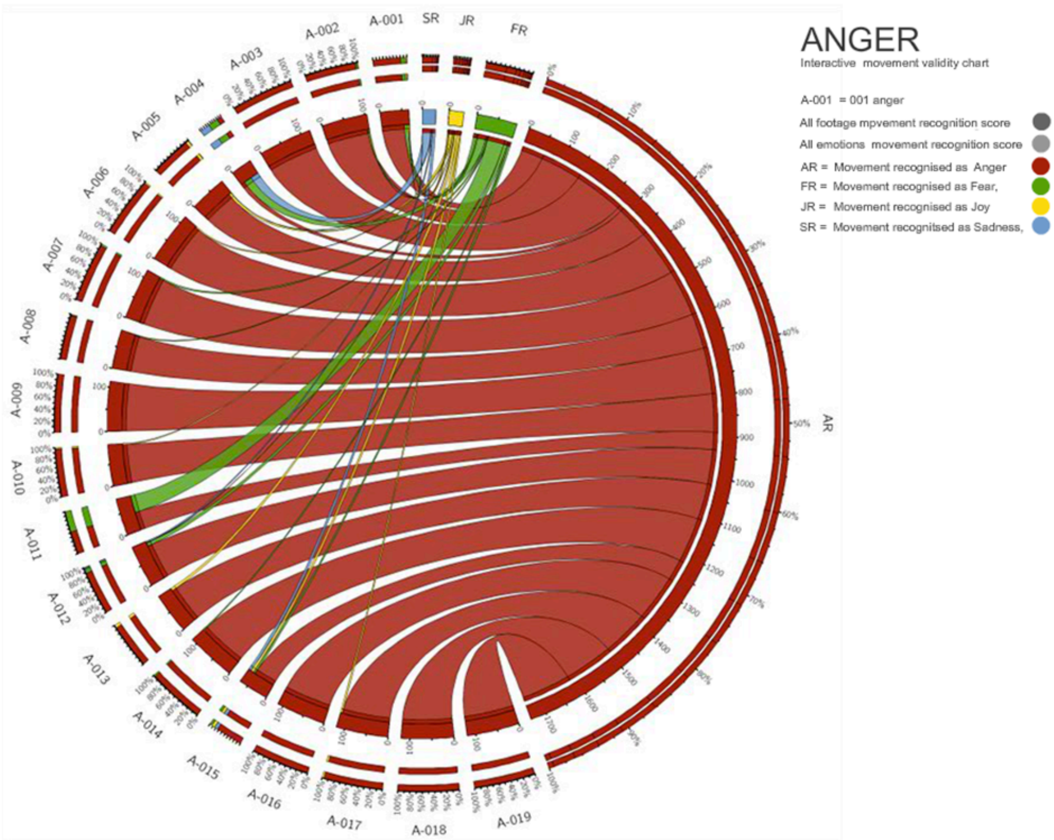


Figure 4.47 Evaluation results for footage representing Anger, Hrynczenko, 2013.

AR - anger recognition (red)
FR - fear recognition (green)
JR - joy recognition (yellow)
SR - sadness recognition (blue)

In this example, the graph colours: green, yellow and blue represent recognition errors. For example, movements in video film A-011 are also recognised as fear and in A-004 both as fear and sadness as indicated by the colours green and blue corresponding to these emotions.

The additional feature, movement timelines overview, provides the possibility of searching expressions according to movement timelines as chronographic charts for all four emotions expressed by each of the performers (figure 4.48). This search feature is included in the same section of the database enabling options to connect a variety of performers expressions with both recognition points and recognition errors.

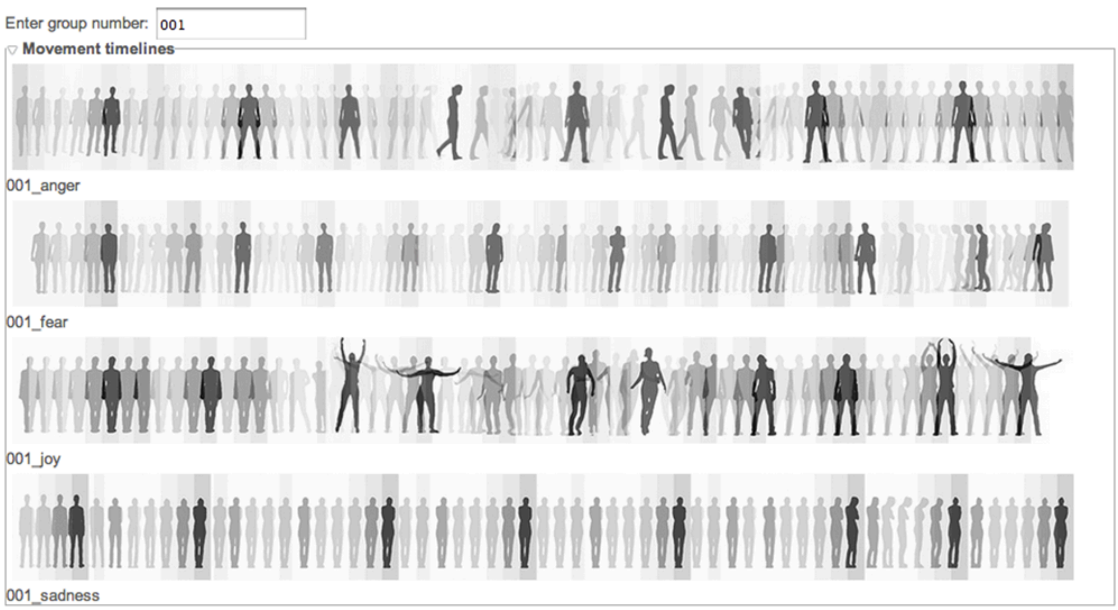


Figure 4.48 Search window and result for performers all timelines, Hrynczenko, 2012.

4.5.5 Summary

In essence, this chapter focuses on the aspects of database construction that is summarised through the description of the workflow emphasising the different phases of database development. The database is published online and contains media such as numerical data, video, graphics, graphs and charts. These represent visual properties of embodied emotions by exemplifying expressiveness, shape, space, volume, time, expressions communicative values and similarities of expressions, among the four investigated emotions: anger, fear, joy and sadness.

The database site is documented and presented in DVD/Video 4; complementary login information for the online database is available in Appendix O.
Development of the database structure in MySQL (MySQL AB,1995) was designed and programmed by Blazej Pindelski based on my instructions, direction and with content focused on information architecture, as a first part of the design. The main objective of this part was to provide an information structure that could be easily retrieved when searched. The prototyping comprises the design and implementation of the interface to the database in HTML according to the mockups and wireframes created in Balsamiq Mockups (Balsamiq Studios, 2008).
During the development of the database an additional feature was created, a simplistic Expressed Movements Collections quiz. The new feature provided an overview of all the videos contained in the PTM database now accessible via interactivity thanks to keywords linking provided by the Korsakow system (Thalhofer, 2007).
Using this feature all video clips are connected to each other by keywords in which movement collections can be accessed only if a user recognises the expressions.

The PTM database information representation via the interface design builds on JavaScript for accessing data allowing communication of the visual information used as primary media in the database.
For this purpose, the ontology of the system is created with regards to metadata about movies and images based on relational dependencies between the system and the interface. The navigation system could be handled from the overview graph or via visual content grouped according to graph collections, timeline charts and thumbnails. For standard navigation, menus are provided. For a quick review of the video content, timelines in the form of chronographic charts are implemented contributing Walk Cycles and key postures at the same time. The search system builds on a visual intuitive approach using the visual elements described above that link to information for each video clip.

In this design, all visual entities support a triangulation method, allowing future comparative visual analysis, a feature designed to collect all representations of expressive movement on one page. This feature attempts to provide the structure that helps to estimate the characteristic movement patterns for each video clip. An additional feature is provided to the database in the form of Visualisations and Statistics page presenting information of validity of documented expressions based on the results from an online survey. This feature renders a visual summary in the form of charts that represent recognition factors of emotions expressed on each video. For this purpose, an interactive applet was produced in Adobe Flash.

The database content provides different visual representations of embodied emotional expressions; however, these represent only a small percentage that potentially could be extended with several new visual representations of emotion, an idea for future development of the PTM database.

4.6 Discussion

The main chapter heading contains the words; "Art as Vehicle" relating to the artistic process where I refer to the various stages and methods applied during the practice-based research. Grotowski (Grotowski via Brook, 1987) used this term primarily in relationship to ancient songs that serve as ritual actions adopted to transform the different forms of energy linked to the forces of life, to instincts and sensuality, and applied by him as a method in the context of performing arts (Wolford and Schechner 2013). Brook (1987, p. 381) in his talk, *Grotowski, Art as a vehicle,* attributes it to ‘something which existed in the past but has been forgotten over centuries. This is to say that one of the vehicles which allows man to have access to another level of perception is to be found in the art of performance.’ Grotowski in his work and research implied a difference between Art as Presentation and Art as Vehicle in the context of spectator directed theatre. In this context, he introduces “vehicle” to the performance art as handcraft, not to the performance style or performance as final presentation. Since 1986, "Art as vehicle" includes work developed at the WorkCentre of Jerzy Grotowski in Pontedera, Italy (Wolford and Schechner, 2013).

In the introduction (section 4.1), I refer to gestalt as a verb "to gestalt" with emphasis on the process, not the final product of this process. All components in this process form together a vehicle to find a visual form for representation of human emotion in a particular context, a form which slowly dissolves in the process of technical development and digitalisation of our daily lives. A process reflected on by Herbrechter

(2013, n.p.), author of *Critical Posthumanism as* ‘an ongoing process of first separating ourselves from our “natural” environments through tools, techniques and technology.’ In the same interview he extends the context by pointing at:

> ...after millennia of tool use and extensions to the human body, contemporary biotechnology in combination with digitalisation threatens to blur the boundary between the organic (human and nonhuman bodies) and inorganic material (machines, digital media) (Herbrechter (2013, n.p.).

The intention of Chapter 4, *Art as Vehicle, Research in Practice* is to map the various levels of the production process where the practice based research elements became an endeavour of the artist exploring scientific methods as tools.

Additionally, and to a certain extent with the purpose of placing human expressive movement and gesture within a context other than that of performance art where as an effect of knowledge categorisations the embodied gesture is usually placed.

The process, in itself, was generated by utilising a knowledge base built on past and contemporary technologies and ideas. During the research, I was taking advantage of new methods, building models and prototypes, testing them, improving them, and completing them as technical designs in the form of schematic flowcharts, technical descriptions, designs, tools and visualisations combined with pedagogical work and physical exercises during the DAMA workshops, which provided the possibility for movement documentation. Consequently, the amount of material generated required extensive formatting, sorting, and labelling. Labelling is a significant part of human nature and becomes an important part of the working process, in which the nuances of expressions dissolve. The workshops, 'hands on' experiments on site or in the editing studio, database creation and visualisations represent the research in practice providing the creative platform, a “space of ideas” (Schlemmer’s, 1928a) reflected ‘on-the-fly’ out of the physical body and space, in order to find practical solutions by testing, testing and testing.

One of the major ideas incorporated in the work process is that every part of it should be clearly integrated within the database as an extension of the original video and visible in the final output of this research. However, several additional movement and posture visualisations were produced as a result of the experimental work which I have decided not to include in the database, based on the fact that these were partly showcasing the possibilities that developed with the material contained within the database. The second reason for this decision comes from my belief that the future database should contain two parts; one with basic material; silhouettes and movements' quantitative data, and the second containing the different results of research based on the material from the previous part where the different interpretations are showcased. My aim is to extend the database in the near future making it possible for students, artists and researchers to publish their own interpretations of data contained in the database.

The name of the project; *Periodic Table of Movements* (PTM) was in the beginning more of a linguistic construction, a manifesto placing human corporeality and corporeal emotional expressions juxtaposed with inherited Cartesian traditions, which from my own perspective as a media, performance artist and gamer, dominate human computer interaction design related to games.
In the course of this research, the 'Periodic Table of Movements' name demanded its own justification via manners and methods that the visual ontology of embodied emotion required to be used as a starting-point for a dialogue with the techno-centred community. In this sense, the name defines the framework in which the research progressed and where the final output constitutes a framework for future research on embodied, human, emotive expressions in the context of its digital manifestations.

Prior to undertaking this research I debated the issue of emotional expressions in relation to new possibilities in the development of new technology, where I argued that it is important to ensure that the emotional presence or subtlety of movement is not lost within the system's interpretation and translation of that movement. My approach is not to avoid technological advancement but to "reclaim" the technology for human physical predispositions. Munster (2006) debates a corporeal virtual experience and uses the term "reconfigured bodily experience" in describing a new level of experience as a "new logic in the non-linear senses." Further, in her statement she describes digital embodiment as a process in which '...individual bodies engage with digital codes to produce new and different sensations and affects' in the process of "reclaiming" the digital space and technology (Munster, 2006, pp. 26-27).

Taking into account my interest in how embodied knowledge could be transformed into cultural phenomena such as gaming, some questions arise concerning how a game's content could look if it were also a tool used to increase human perception based on human corporeal movement. Reclaiming" is an ongoing process visible in this investigation, aiming to convert expressive movement to digits and then, transform

them into graphical representations to accentuate the vital importance of the human body and physical actions. I adopted Munster's (2006) "reclaiming" as an act of manifestation, to obtain the necessary tools and to reorganise in order to translate emotion into the visual language that makes the properties of human expressiveness visible: emotional space-x and y coordinates/movements volume; body-body shape; time-expressions quantity over the time; relation-similarities and differences among homologous expressions.
The development of technology, such as multiple modalities of input and specifically Natural User Interaction (NUI) with the introduction of Kinect (Microsoft, 2010), , real-time depth imaging, has brought a paradigm shift for many artists and game developers, as well as in my working process and research, changing the circumstances and simplifying my work. At the same time, body-centred knowledge has entered the game development scene, intensifying research into the human body as a possible interface. Based on the contextual research I found it evident that, in the area of the human whole body movement and gesture, those innovative projects are based on cross-disciplinary cooperation encompassing knowledge from different fields.

This approach is also visible in my own research where several collaborations took place in different parts of the database development as described in section 2.2.6 *Collaboration and Collaborators.*

The development of the database has proceeded simultaneously on many levels in an attempt to bridge visual, embodied and empirical/verifiable knowledge. This journey's first step was to document interpretations of embodied emotions performed by workshop participants. This was often generated as a result of participatory co-operative workshops combined with discussions involving the DAMA Network, game, performance, audio-visual and computer science communities. The discussions often revolved around the concept of performativity embracing the notion of emotional presence and the differences between the real emotional state and its interpretations. Consequently, the documentation sessions become a playground for improvisation as a creative approach to movement reversibility, which refers to the knowledge that specific movements can give rise to particular emotions (Gurdjieff, 1933; Isbister 2011; Cuddy 2012). Over this course of events, the workshops and documenting process became learning loops where the generation of knowledge in the space between all the components of my practical work took place.

The workshops (described in Appendix P) are an example of research in practice acting as a vehicle to examine the core elements of this research; physical movement, new technology, games, all connected together within an educational context. This is a dream scenario for an artist and educator by using this doctoral study to promote more research and knowledge production on human emotive gestures in virtual environments. In the context of database creation, the workshops serve as a platform for discussion and documentation of expressive movement. In parallel, the workshops and the artefacts produced by the students serve as an argument for cross-disciplinary platforms in education where knowledge between dance media and games can merge.

The second main milestone of the practical work was to resample the collected material in the form of new visual interpretations and compile all the material in the database, where the process of sorting and labelling turn out to be a central part of the final result. In the quest of searching for pattern characteristics of each emotion, movement sequences have been interpreted with the help of tools for movement analysis and numerical data visualisations.
As previously mentioned, it was important during the work process that every part of the database should be clearly evident in relation to the silhouettes in motion videos. The transition between the emotional state documented on video and its expression in numbers is my attempt to grasp the reality in which most parts of human life are filtered, translated, analysed and collected in digital databases where numbers generate patterns. These transitions from statistical data conveyed to charts and graphs often formulate the basis on which significant life decisions are made by scientists, sociologists, economists and politicians. Therefore, by replicating the process of data convergence and flow my intention was to highlight the deficiencies of digitalised emotions as only a simplified reflection of the real world's complex interactions and dependencies.

In accordance with the discussion above, translation of emotions from statistical data to visual patterns is a simulation of the digitalisation process that all of humanity is subject to. Here, digitalisation is referred to as the extended digital reality we are involved with in our daily lives. In my own process during this research, the transformation from preformed and documented emotion to charts via statistics and network data is used as a symbolic act. However, I use the same process as a method to validate the reliability of human embodied expressions in order to literarily digitize the emotion with the purpose of amplifying the empathetic reactions both for users, as well as for avatars in games. From my point of view, the contradiction is considerable and problematic since my humanistic ideas conflict with the 'cybernatural' posthuman reality. ‘Cybernatural’ in the context of post humanistic theories is identified by Waldby (2000) as ‘second nature’:

> The cybernatural designates any practice which uses the space of the virtual screen as a space of ‘second nature’ through a conflation of information with vitality (Waldby, 2000, p. 121).

Returning to my process in which emotion is quantified, from my point of view, these are still just interpretations whereby the line between the objective and subjective view is diffused. My intent is to highlight the process by implementing the same mechanisms of the digital conversion used today in information processes. In other words, as Deleuze and Guattari (2004, p. 344) state: ‘to join with the World, or to meld with it. One ventures from home on the thread of a tune, where art often proclaims the ‘line of becoming’. According to Deleuze and Guattari (2004), it is through ‘becoming’ that we can bring the new into being. The transition between emotions and numbers needed a medium for elaboration and representation in which data visualisation became my choice to illustrate these transitions.

Deleuze and Guattari (2002) proposed displaying a model through a diagram as an abstract machine to elaborate thought and expression. In my own working process, charts and diagrams become a form of interpretation and a theoretical argument explored through their visual structure and at the same time a structure of thought. De Landa (2000a) in the analysis of Deleuze's interpretation of diagrams, *Deleuze*, *Diagrams*, *and the Genesis of Form*, points out that the form of the diagram is a way to structure it without a definite form; ‘a function-expression having only tensors, as in a system of mathematical, or musical, language’ (Deleuze via De Landa, p. 37). This thought is explained by both Deleuze and Guattari in A *Thousand Plateaus* (2002).

> An abstract machine in itself is not physical or corporeal, any more than it is semiotic: it is diagrammatic... It operates by matter, not by substance; by function, not by form...The diagrammatic or abstract machine does not function to represent, even something real, but rather constructs a real that is yet to come, a new type of reality (Deleuze and Guattari, 2002, pp. 141-42).

An idea of the diagram in its graphic form has an explanatory function; it is not serving as problem solver but as problem-posing. In this study the diagrams and charts are

explanatory tools investigating and clarifying structure and form reflecting the shape and spatiality of emotion represented as human body movement. In terms of structures, the final representation of investigated emotions, the Periodic Table of Movements creates a consistent structure, yet rendered only for four emotions. However, the investigations focused on the correlations of similarities and differences, firstly, expressed by a rhizomic structure, and secondly as an organised correlation network that during the last phase of the research had taken the current form of the Periodic Table of Movements.. Although, it is a visual form that has function, mainly, it is used to highlight the similarities and differences of emotive expressions. The visualised correlations of bodily expressions provide a reference for character design as well as a reference for kinaesthetic game design built on depth sensing, a feature built into movement sensing devices such Kinect (Microsoft, 2010).
However, these visual representations of the properties of emotions and these correlations should not be seen as representations of a norm, these are interpretations from my point of view. The scientific evaluation methods used and artistic means for the representation of the results, is an exploration of possibilities that occur when merging different perspectives on research methods in relation to the subjective-objective point of view. According to phenomenological perspectives, (Merleau-Ponty, 1971; Crossley, 2001), or sociological viewpoints (Mauss, 1979/1935), there is no absolute observer. Similarly, as Merleau-Ponty points out through the example of a house, there is no absolute object.

> The house itself is not the house view from nowhere, but the house view of all parties. The finished object is translucent, is penetrated from all sides by a current multitude of looks that are cut in its depth and leave nothing hidden there (Merleau-Ponty, 1971, p.82).

In other words, Merleau-Ponty ponders that the object does not exist by itself. The objects existence depends on how it is seen and perceived by others. Through the metaphor, he points out that a house is not defined by the sum of its objective appearances, but by the quantity of the eyes that look at it. From the point of view of Mauss (1979/1935), even the perspective we use to look through is conditionally filtered by our own history, socio-cultural and political background.

The socio-cultural, geographic and gender factors that affect emotive actions of the one who expresses them is not investigated in this study. As a method, however, these parameters were explored as quantitative data in the context of communicative values based on the Expressive Movement Recognition Survey. Namely, to look if there were any considerations for future research in terms of how emotions are recognised from the socio-cultural, geographic and gender factors. A small study was conducted but mainly treated as a pilot experiment, due to the small participant sample size, and used to explore statistics and data visualisation methods as described in section 5.2.4.3 *Analysis According to Respondents Personal Data*. However, in terms of the future development of the database, these issues will be approached by providing both the participants' and the viewers' perspective via visual and symbolic contextual features.

Finally, in relation to the research question, emotions expressed by movement are documented in different media formats in order to preserve the complex variety of expressions. The content is divided according to the database structure in which the four emotions investigated: anger, fear, joy and sadness are analysed in terms of their visual properties. In this regard, these are divided by shape, space, volume, time, communicative value and the expressions similarities across four emotions. These parameters are visualised and developed as epistemic objects for future exploration in the context of educational material and research in game design and graphics. The visual data based on exaggerated movements / key postures was analysed in terms of readability by sensing devices and in the context of character development for games. However, the visualisations are based on the analysis of quantitative and qualitative data in which scientific methods were used as a basis for this process.

'No science without fancy, no art without facts', is a statement by scientist and writer Nabokov (via Gould, 2003, p. 53) that appropriately describes the final output of this research in the form of a database and the Periodic Table of Movements. In the next Chapter 5 *Outcomes and Evaluation*, the scientific approach is presented.

5 Outcomes and Evaluation

Don't try to create and analyze at the same time. They're different processes. Kent (via Cage, 1967, unpaged)

In the first part of this chapter, experimental empirically validated results are presented. The second part is dedicated to the analysis of the results and description of the processes adopted during the research based on quantitative and qualitative research methods.

The evaluation of the research is divided into two parts, each governed by different logic that take into account the duality of the research approach. In Chapter 4 *Art as Vehicle, Research in Practice,* artist processes and reflections are presented based on the intersections of creative and critical methodologies where both artefact presentation and a discourse format are used. However, in this chapter *Outcomes and Evaluation,* the same process is presented from the scientific point of view using scientific evaluation methods. However, the results described through this investigation do not have the ambition to be scientific per se. Through this approach practice-based research became a practice-led investigation of a scientific method applied to work based on artefacts and an attempt to articulate practice-based and creative research within academic contexts. The primary focus was to advance knowledge within my practice as the artist and designer. However, during the evaluation of artefacts such as the expressive movement documentation, quantitative methods became my tools for explorations of data aesthetics that resulted in new artefacts classified in this chapter as “primary, secondary, and tertiary artefacts”. These are based on quantitative data or combinations of both qualitative and quantitative data. This method of classification provides perspective on the process by classifying research results in terms of the many iterations of artefacts and production based on the video material, i.e. the primary artefact. In the evaluation process the four emotions are disected, quantified and squeezed through the statistical calculations in order to build first rhizomatic then clustered networks. In the previous chapters where my person is present, my subjective voice, my thought, my body and eye relate to actions in the context of the many layers of embodied emotion. Questions such "How?" and "Why?" are explored, and my detours are exposed in parallel to the research processes. In juxtaposition to the previous investigations, in the next chapters my personal voice is absent, but not the eye of the artist. In the next sections, I explore conventional evaluation methods used by science, which provided the grounding for the artistic visualisation process described previously.

5.1 Outcomes of the Research

This section presents short descriptions of the outcomes of the practice-based research created during the different stages of this doctoral study. The majority of artefacts presented in this section contribute to the database content with the aim of showing emotive whole-body movement from different perspectives based on the visual properties of emotion. The database is used as a medium to present these different features designed as a tool for analysis, experimentation and research. Mainly, it is intended as a framework open to students, teachers, artists and researchers to publish their own interpretations of the data contained in the database. The choice of emotions presented in the database is based on Plutchik's (2001) psychoevolutionary theory of basic emotions grounded in the adaptive pattern of human behaviour necessary for survival. Plutchik postulates that eight basic emotions have formed throughout the evolutionary process creating four bipolar pairs: Joy v. Sadness, Acceptance v. Disgust, Fear v. Anger and Surprise v. Anticipation, analogous to the colours on a colour wheel arranged into sectors comprised of 32 emotions, according to their emotional intensity. In this research these eight emotions were documented on video, however, as an effect of the contextual research on the universality of emotions, only four emotions; Anger, Joy, Fear and Sadness were chosen as the basis for the database, as these were the most representative in a cross-cultural context. The pre-design process illustrated in a *Cross-disciplinary Knowledge Map* (CDKM), (Appendix C), offers an overview of contextual studies creating a knowledge map for conceptual development of the database. The post-design process is illustrated in the *PTM System and Database Infographics; a Proposal for further development of PTM database with movement sensing devices* (Appendix D), summarising the study by proposing and explaining PTM functions in relation to motion tracking devices. The visualisation of the Periodic table of movements is an example of an explorative investigation of correlations among expressive gestures across four different emotions; anger, fear, joy, sadness, and showcases how visual material contained in the database could be used as a tool for the research of emotions and corporeal movement.

5.1.1 Cross-disciplinary Knowledge Map (CDKM)

CDKM is a cartographic overview of knowledge areas connected to the PTM development, used during the contextual research in order to map possible knowledge convergences within the scope of expressive movement research. At the same time the map aims to connect existing knowledge and research in the context of the corporeal experience as encompassed in the four 'existentials' a heuristic guide of Phenomenology reflecting on human experiences: lived space (spatiality), lived body (corporeality), lived time (temporality), and lived human relation (relationality or communality) (Van Manen, 1990, p. 102). The map is primarily an example of a feasible contextual research method, and secondly of potential interest for future cross-disciplinary research.

5.1.2 Expressive Movements Documentation and Timeline Charts

The collected data set includes 152 video representing 8 basic emotions; anger, anticipation, disgust, fear, joy, sadness, surprise and trust. However, 76 videos of four emotions: anger, fear, joy and sadness were converted to silhouettes in motion through the postproduction process and archived in the database. This collection constitutes the primary data set based on video data from which several artefacts were produced. Additionally, a secondary set of 76 digital images representing movement patterns were created as superimposed video frames based on the video footage, compressed and exported from Final Cut Pro (Apple, 2010) as stills and combined in a single timeline in Photoshop to form chronophotographic timeline charts. This set of images was compared with Movement Graphs in the triangulation process to find similarities in emotive expressions. In the visual ontology of emotions embodied in expressions the parameters investigated are shape and time, and shape and time together according to parameters that describe the movements.

5.1.3 Movement Graphs Based on Analysis of Video Data

The movement data investigation includes video analysis utilising VideoAnalysis software (Jensenius, 2007-2012). described in section 4.4.4 *Visualisation of Kinematic Data, Emotions as Diagrams.* The video analysis produced 76 datasets based on quantitative data providing a basis for the graphic visualisation of movement. These secondary artefacts form two collections of graphical visualisations of movement. These contain: 76 graphs of xy positions and 76 graphs of the quantity of motion in relation to time. Both collections are included in the PTM database contributing to expanded variations of movement documentation. The video analysis method has contributed to the large volume of artefacts in the form of movement graphs, complementing previous material with information about the registration of movements' position and intensity in relation to time and space.

5.1.4 Graphs Based on Analysis of Survey Data

Emotion Recognition Graphs are based on statistical data obtained from the Expressive Movement Evaluation Survey (EMES), which provided information in the form of emotion recognition points for each video clip. Using Circos data visualisation software (Krzywinski *et al.,* 2009) five charts were produced, four charts for each emotion and one that visualises the correlations among all emotions. The same tool was used for visualisation of the survey results for colour recognition according to emotions presented as Colour Recognition Graphs.

5.1.5 Interactive Video Collections, Movement Recognition Quiz

These video collections are a secondary video set containing miniatures of the original video clips, produced using the Korsakow tool (Thalhofer, 2007), a database system for creating non-linear narratives and navigation in a linear medium such as video. In the PTM database this is an additional function of the main database with the option to present all video footage of each emotion for movement analysis and overview. Each of the four collections consists of 19 videos that allow the content to be viewed through a mouse-over function. This approach provides the option to stop and start the video and freeze the frames when analysing specific shape characteristics of gestures and movements. In the context of the aims of the research, this part of the study investigates the visual property of emotion such as shape. The collections are presented in the form of a quiz that challenges the user's ability to recognise specific movement expressions for four emotions: anger, fear, joy and sadness.

5.1.6 Database

The PTM database aggregates the video and visual material described above, presenting the visual characteristics of four emotions; anger, fear, joy and sadness identified by expressive movement, gesture, movement data visualisations and additionally with colour added to provide visual differentiation amongst emotions.

The database contains a collection of digital assets that emphasise the properties of emotive expressions as visual concepts in which these features are presented in terms of shape, space, volume, time and the expressions similarities and differences. The assets are primarily collected to serve as an educational framework and in the context of character development for games and expression readability for movement sensing devices.

The interactive system of the database provides information retrieval through searches by emotion, colour or video filename and via thumbnail collections. The general construction of the archive presents three different perspectives of expressed emotion; spatiality, corporeality and temporality, inspired by phenomenological inquiry. Emotive, whole-body movements and their relationships to space i.e. spatiality of emotional expression, is described by 2D space, based on the xy coordinates of movements retrieved from video data analysis and contained in visual charts. Movement corporeality is visualised by silhouette motion in the video created by the expressive movement documentation of 19 participants. Temporality of expressive movement and gesture is visualised by chronophotographic timeline charts of movements describing the quantity of motion in relation to the movement of time. Additional information has been included in the database consisting of interactive movement collections according to each emotion based on the Korsakow system (Thalhofer, 2007) and data visualisations in the form of charts representing statistical data based on the results of the reliability test provided by the online survey. Based on Plutchik's Psychoevolutionary Theory of Basic emotions (Plutchik, 1984) and his colour wheel, a colour tagging system was used for sorting emotions according to colours, both as a possible search query and also in the interface design.

5.1.7 Workshop Documentation Data and Pedagogical Toolset

The documentation presented in Appendix P contains the output of the 5th DAMA workshop held in Tallinn, the 6th DAMA Workshop held in Reykjavík, the 7th DAMA Workshop held in Visby and a description of the pedagogical tools used. The visual material is based on the cooperative and participatory practice based work each of the workshops presented in the form of students work, such as exhibitions and performances. The workshops are documented in the form of visual material such as digital stills from rehearsals, locations and presentations. The pedagogical toolset used during the workshops is presented in section 4.2 *Pedagogical Toolset* in the form of short descriptions and stills comprised of a print based on a collection of stills documenting a *Shadow Dance* (Hrynczenko, 2009a) a motion responsive tool and a movement based rehearsal method**.**

5.1.8 System and Visualisation of Periodic Table of Movements PTM

The materials contained in the database provide the foundation for analyses of emotions, a triangulation based on visual evaluation of silhouettes in motion; in this sense, the final data is a tertiary set containing both printed and digital artefacts. The analyses are focused on postures extracted from key frames of the most frequently recorded expressive gestures, with a labelling system suitable for computational processes. The final outputs of this sequence are four charts, two that illustrate the movement recognition process and two that present the Periodic Table of Movements (PTM). The final visualisation presents the most common expressions for each of four emotions (anger, fear, joy and sadness) and the correlations among the seventeen most common expressions of four emotions in the data sample.
The collection of graphs contains:

- chart of skeletons and silhouettes of the most common postures for anger, fear, joy and sadness
- chart of letters that symbolically describes the differences among the expressions
- Graph representing the ranking and correlations system among expressions
- final circular PTM diagram, a colour chart that highlights the relation of most common expressions among four emotions; anger, fear, joy and sadness.

The aim of this part of the study was to look at the correlations among emotional expressions collected in the video clips. Mainly, the focus lay on the possible methods useful for visualisation of similarities and differences among emotive gestures.

5.1.9 X-ray of Emotional Kinesphere

X-ray of Emotional Kinesphere is a collection of expressive movements visualising the personal space of whole-body movements by exploring relationships of body, time, space and volume. In the context of the aim of the research, this additional study explores the visual properties of emotional expressions in terms of space, volume and the expressiveness of gestures. The collections offer a secondary set of digital images from video clips in an attempt to exemplify possible use of the material contained in the database, and to visualise emotional expression in an alternative way by applying digital tools commonly used in scientific research in life sciences. The collection contains 76 digital visualisations of emotional expressions based on video documentation of four emotions; anger, fear, joy and sadness, performed by each of the participants, and four visualisations of each emotion containing all expressions on the same diagram.

5.1.10 Infographics; PTM database for Kinect

The infographic graph visualises the functions of the PTM database in the context of further developments, presented as a schematic flowchart that describes possible construction of the PTM database connected to the movement recognition device, Kinect (Microsoft, 2010). The objective of this visual description is to provide a platform for future development of the software for the comparison of movement patterns where the database is functioning as a reference model. Whole-body movement data collected from Kinect's depth sensor could be compared with the visual patterns of particular emotions contained in the PTM database. In terms of game design, the system potentially offers reference objects that could be used as a foundation for game Mechanics, Dynamics and Aesthetics (MDA).

The flowchart additionally describes possible features for the output information and proposals for potential application areas. The intention of this project is to investigate the open, relational systems of the database for future tools that will augment real-time performance. This concept incorporates a proposal for feedback, namely, time-based media replayable for the user/spectator in real time, which allows for an interactive synergy and integration between physical movement and the digital database. The primary aim of this construction is to incorporate a player's movement and gesture necessary for 'Kinesthetic' games, which requires physical and cognitive input from the player in order to overcome the challenges of the game.

5.2 Evaluation

The evaluation serves the development of methods for the data visualisation of shape, and the spatial and volumetric properties of whole-body movement and gesture. Equally, the same assessment provides database users with a visualisation of a communicative factor value of the expressions, for each of the video clips, based on the four emotions: anger, fear, joy and sadness. This is a feature that indicates the expressiveness of gestures contained in each of the video clips useful for the development of narrative content. At the same time, the readability of expressions is valuable in the context of input for motion sensing devices such as Kinect (Microsoft, 2011b).

The following evaluation is divided into several parts tracking the iterative model of investigation wherein the outcome of the quantitative study based on statistical data and video analysis constitutes a foundation for the triangulation methodology. The triangulation summation; visual and quantitative data of relationships and distinctions among whole-body expressions of anger, fear, joy and sadness, creates the Periodic Table of Movements' correlation table in terms of the visual properties of emotion's shape.

5.2.1 Silhouettes in Motion, Documentations Process and Video Data

During the first part of this research, documentation and a catalogue of video samples of whole-body gestures as silhouettes were produced and used for the online survey. The intention was to provide quantitative and visual data objects of expressive movements for the PTM database. In the context of this study, video samples were used for statistical and visual analysis of correlations between emotions and physical expressions represented in the video clips.

The movement documentation phase of the research involved a series of workshops in collaboration with the DAMA network (se section 2.2.6 *Collaboration & Collaborators* . In order to bring variation of expressions into the documentation material and get better video quality, an additional recording session studio was built for the workshop in Stockholm where previous technical issues regarding lighting conditions were corrected. The video material produced at the workshops in Tallinn and Reykjavik was only used as experimental material and is not included in the database or the online survey. The main idea of the DAMA workshops was to provide the venue and opportunity for participants to experience different approaches; where dance and performance art students could explore media technology while software, hardware and media arts and programming students tested corporeal movement and gestures. The combination of workshop and PTM research goals provided a good working environment for movement documentation.

5.2.1.1 Participants

During the first iteration of the video recordings 10 workshop attendees participated; six dance and four media students consisting of six females and four males between the ages of 21 and 51 (average = 26). In the second recording session three females and two male participants from the media arts and dance departments aged 21- 28 (average = 24) were included. In the third iteration ten participants with varied backgrounds, including writers, artists, social workers, performance art students and other professionals took part. Five were female and five male, between the ages of 22-60 (average = 36).

The third and final session was comprised of nine attendees; five females and four males between the ages of 22 and 36 (average = 28). The subjects were recruited through the DAMA network at the beginning of each workshop. Participants in Stockholm were recruited through an advertisement on social network sites such as Facebook, Twitter, and through face-to-face approaches.

All subjects participated in the research voluntarily and gave informed consent and all procedures for the video recordings were reviewed and approved prior to the workshops by The Research Ethics Sub-Committee of the Research Committee of Duncan of Jordanstone College of Art & Design at the University of Dundee, Scotland, U.K.

5.2.1.2 Methods and Technical Description

The recording sessions required voluntary participants to perform eight different emotions: joy, trust, fear, surprise, sadness, disgust, anger and anticipation in front of a camera during one session within the time frame of 30 seconds for each emotion. The video footage was grouped into clips based on the emotion and numbered according to the time the footage was recorded.

During postproduction in Final Cut Pro (Apple, 2010) and After Effects (Adobe, 2011) the video material was transformed to silhouettes removing the participants personal characteristics providing at the same time uniform visual material for expressive movement recognition. Finally, the video material was converted to .4fv file format to suit both the online questionnaire and the database. The documentation process and survey were carried out in accordance with the research ethics of the Duncan of Jordanstone College of Art and Design ethics guidelines (Appendix E) and University of Dundee Ethics and Research Governance Policy, described in detail in section 2.3 *Ethics.*

5.2.1.3 Evaluation Summary for Video Recordings

During the documentation process at least four different parameters had to be taken into account: the technical circumstances under which the documentation was taking place, the participants background, their ability to act on demand, and the degree of my own involvement (directing). My involvement was mainly restricted to the preparatory exercises, during which expressiveness of gestures was discussed and analysed together with the participants. Some 60% of the participants were media art students and 40% came from dance/performing art education, therefore, acting was a new experience for the majority of the students. The issue of presence and especially their self-consciousness in front of the camera sometimes became problematic for inexperienced students. The participants were given freedom to quit the recording session if they felt uncomfortable to proceed, however all of the students chose to continue. The preparatory exercises contributed to the participants curiosity toward physical acting and an overall positive approach to the video recording sessions in which the playful approach provided useful gesture and movement exaggeration. This approach contributed to better readability of the emotions being expressed. However, problems developed during the studio work, related to technical issues such lighting and students abilities as well as their varied experiences of spontaneous acting on demand. This sometimes affected the fluidity of movements during the video recording sessions. The lighting issue was to a large extent addressed by higher contrast software values used during the post-production process. The jerkiness of movements, i.e. broken movements that stop and start within some of the video clips were left as recorded without further editing.

After two sessions, where most of the participants were media art students in the age group from 22 to 27, the need for variation in the participants age range and experience became obvious in order to bring greater movement variety to documented expressions. A workshop session in Stockholm offered an opportunity to try a different approach by recruiting participants of different ages and backgrounds as well as to correct previous problems with lighting. The previous technical problems with the lighting on different sites affected the video material quality, prolonging the postproduction process. Therefore during the session in Stockholm a special studio was build taking into consideration the previous problems.

During all three occasions, the documented movement was based on the participants interpretation of enacted emotions and not an expression of their emotional state. The documentation of exaggerated movements communicating the four emotions is based on how participants think the movement should look if performed on stage. Therefore, based on the participants comments and the video analysis, it is reasonable to infer that this is a non-nuanced exploration of the kinaesthetic memory of the collective perception of physically expressed emotion. This issue is discussed in section 4.3.4 *Comment on Recorded Embodied Emotion* in the context of the socio-cultural dimension of emotions as well as on these bodily expressions (Miyamoto and Ryff, 2011; Mauss, 1979/1935; Foucault, 1995). This conclusion is based on the participants subjective mimicking and interpretation of how emotional expressions are depicted through external media channels such as news broadcasts, advertising, movies and computer games. On the one hand the documented material shows to what extent we are able to recall embodied memory, while on the other it is an additional filter of how emotions are represented in popular media.

In order to determine whether the emotions recorded as silhouettes are recognizable, and to what extent, a questionnaire was published online where 25 responses were used as a basis for the statistical data that is attached to each of the recorded expressions in the database. More information on the questionnaire is presented in section 5.2.4; *Emotions as Silhouettes in Motion, The Online Survey.* From the perspective of the research goals, the collected video data became the framework on which the research continued to develop, creating secondary and tertiary visual and qualitative data.

5.2.2 Description of Circular Diagrams

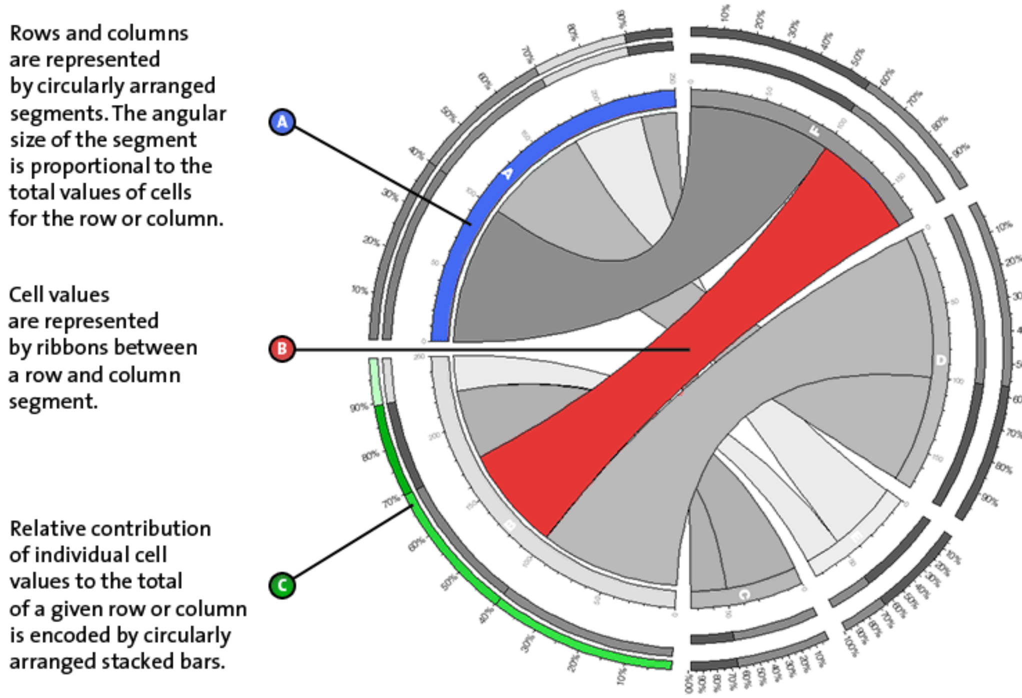


Figure 5.1 Screenshot, Description of circular diagrams' functions, Krzywinski, 2009.

For data visualisation circular diagrams were created using Circos (Krzywinski *et al.,* 2009) Perl script (Wall,1987). The diagram is specifically designed to visualise the relations among data entities in a circular format. For a better understanding of Circos visualisations, a screenshot of Krzywinski's (2012) visual explanation and his explanatory text is provided in figure 5.1.

Segments are arranged (clockwise) by their label value. Ribbons are positioned (clockwise) by decreasing size. Tick marks (numbers in inner circle) provide an absolute scale that indicates ribbon thickness corresponding to the cell value in a table, and segment size, which matches row or column totals. The numbers in the outer circle represent the percentage from 0% to 100% that is the total in the row or column.

5.2.3 Colours and Emotions Survey Experiment

The study that took place during the DAMA workshop in Tallinn was an experiment that investigated the association between colours and emotion; a study aimed at gathering sample data for an experiment with data visualisations tools. The investigation was driven by my curiosity regarding the extent to which the perception of colours in relation to emotions based on gender, cultural and geographic parameters differ from Plutchik's classifiers of colours according to emotions defined in his wheel of emotions. Therefore, the specific question for the first, preparatory study was: To what extent do colours associated with emotions, correspond to Plutchik's conceptual colour classifiers in his wheel of emotions? This exercise served as a preparation for the second study, the online survey and an investigation into data visualisation techniques by providing the platform for experimentation in which different kinds of diagrams were explored.

5.2.3.1 Methods and Technical Description

The method selected for the study was a survey based on a dichotomous i.e. closed-ended questionnaire containing six questions. Eighteen media and performance art students participated in the face-to-face interviews. Two types of questions were included in the questionnaire; categorical and multiple-choice questions. When using categorical questions respondents have to identify themselves within a category: gender, age, background (for example, performance arts or media arts) affiliation and country of origin. The multiple-choice questions required participants to choose one answer from an established answer set, which in this case was a graphical representation of Plutchik's (2001) classifications of eight basic emotions: anger, anticipation, disgust, fear, joy, sadness, surprise and trust. Eight emotions and eight colours were proposed according to Plutchik's Evolutionary Theory of Emotions (Plutchik, 1984),(See template questionnaire in Appendix F).

5.2.3.2 Description of Participants and Recruitment Methods

The groups participating in the study included 18 students; 12 woman and 6 men, from Media and Dance departments in Finland, Estonia, Iceland and Lithuania, recruited during the DAMA workshop in Tallinn by face to face recruiting.

5.2.3.3 Analysis of The Results for Colours and Emotions Questionnaire

The results of the survey are represented as visual and quantitative data based on answers from the 18 respondents on how they perceive the relationship between colours and emotions according to the questionnaire in Appendix F. The questionnaire results are represented in: Table 1; *Plutchik's colour classifiers for basic emotions v. colour classifiers of emotions by student choice* and figure 5.2. Whereas in Table 2; *Votes for Pluchik's colour classifiers for basic emotions as the % sum of student recognition,* the statistical measurements are aggregated as the sum of total answers and converted to a percentage as shown in figure 5.3. For visual representations of data as circular graphs the Circos (Krzywinski *et al.,* 2009) tool described previously was used.

The same statistical data are presented as chartsin Appendix J: *Statistical Data Samples for Plutchik's Colour Comparison* **re**presenting a reference to Plutchik's Colour Wheel (2001) containing all the emotions and colours based on his own definition (Appendix J). Eight colours labelled with eight numbers were used as the basis for the answers in the questionnaire (Appendix F). These eight colours correspond to the eight basic emotions in Plutchik's Colour Wheel; warm-green for trust, cold-green for fear, blue for sadness, grey-blue for surprise, violet for disgust, red for anger, orange for anticipation, yellow for joy and grey-blue for surprise.

According to the students votes, the colours red and yellow equally represent 56% of the recognition factor of colours in Plutchik's emotion colour classifiers in his diagram (i.e. 10 votes each), followed by the colours grey-blue 39% and warm-green with 33%. The colour orange received 22% followed by violet with 17% of votes. The colour cold-green gained only 11% of votes where colour blue was not recognised at all as a representation for surprise. From the collected data set, it appears that the students choice of colours versus emotions applies to some extent to Plutchik's classification of colours versus emotions and only to the colour red as representative of anger and yellow for joy.

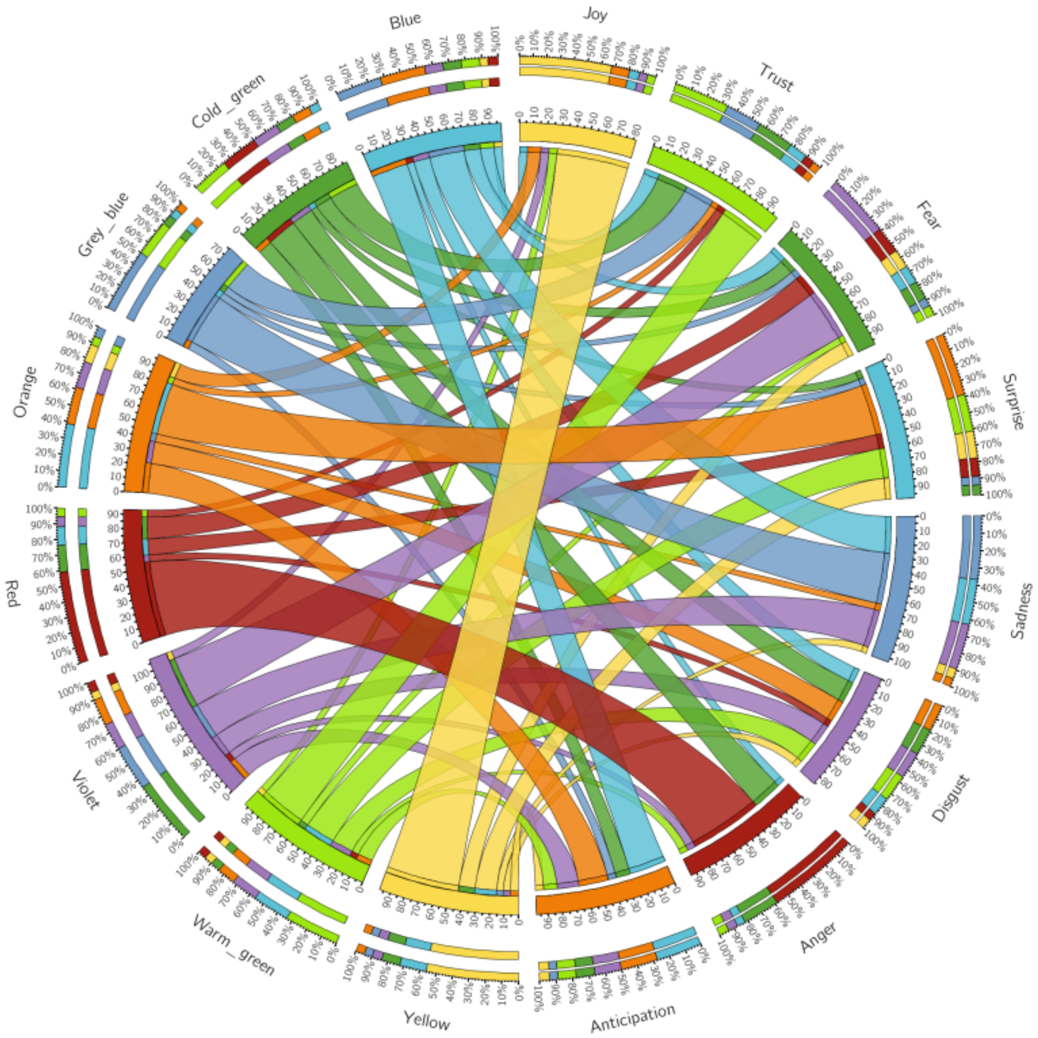


Figure 5.2 Diagram based on table 1, Votes for Plutchik's colours of basic emotions, Hrynczenko, 2013.

Table 1 Plutchik's colour classifiers for basic emotions v. colour classifiers of emotions by students' choice.

%	Trust	Fear	Surprise	Sadness	Disgust	Anger	Anticipation	Joy
Warm-green Pl. Trust	6	1	4	0	3	1	2	2
Cold-green Plut. Fear	4	2	1	0	3	4	2	0
Blue Pl. Sadness	2	2	0	5	2	1	5	1
Grey-blue Pl. Surprice	4	1	1	7	2	1	1	0
Violet Pl. Disgust	0	7	0	4	3	1	3	1
Red Pl. Anger	1	3	2	0	1	10	0	2
Orange Pl. Anticipation	1	0	7	1	3	0	4	2
Yellow Pl. Joy	0	2	3	1	1	0	1	10

Pl. = Plutchik's colour classifiers

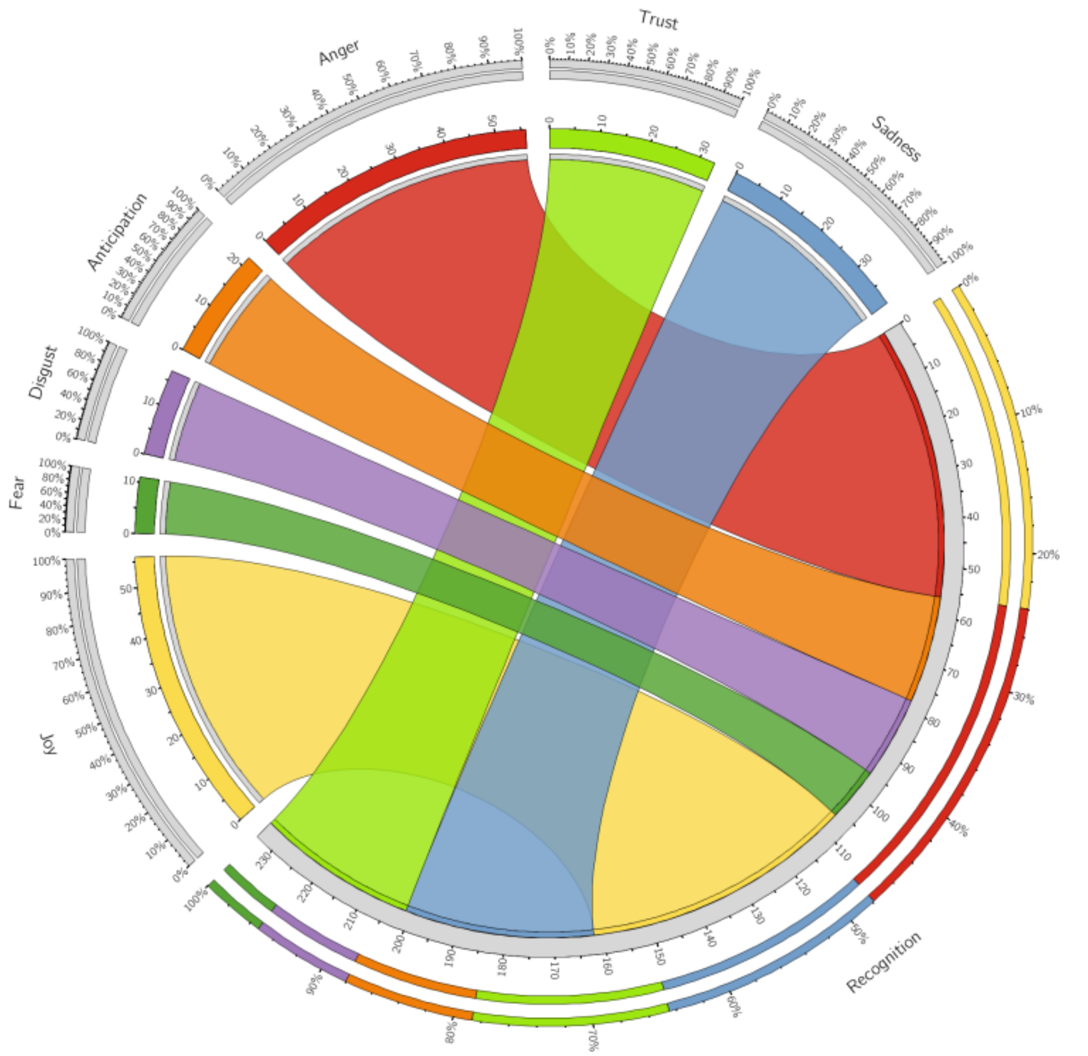


Figure 5.3 Diagram according to table 2, Pluchik's colours as sum of recognition by per cent, Hrynczenko, 2013.

Table 2 Votes for Pluchik's colour classifiers for basic emotions as sum of students recognition per cent.

	Recognition %
Joy = Yellow	56%
Trust = Warm-green	33%
Fear = Cold-green	11%
Surprise = Blue	0%
Sadness = Grey-blue	39%
Disgust = Violet	17%
Anger = Red	56%
Anticipation = Orange	22%

5.2.3.4 Summary

This part of the investigation was based on the quantitative data analyses that are used for the purpose of concept development and data visualisation. The data has limitations based on the small number of participants, however, the study made it possible to use the data samples for experiments that allow explorations of techniques suitable for data visualisations.

The samples provide information on tendencies that could be summarised as follows: the colour yellow for joy and red for anger most closely matches Plutchik's (1980) colour wheel metaphor used in his concept description of emotions, followed by grey blue for sadness and warm green for trust. The emotion surprise did not produce a match at all with Plutchiks's Colour Wheel.

The samples provide information on tendencies that could be summarised as follows: the colour yellow for joy and red for anger most closely matches Plutchik's (19801) colour wheel metaphor used in his concept description of emotions, followed by grey blue for sadness and warm green for trust. The emotion surprise did not produce a match at all with Plutchiks's Colour Wheel.

There are several examples of artworks and research that explore relationships between colours and emotions. The most noteworthy are described in section 3.2 *Emotions, Science, Art and Virtual Worlds* a part of the contextual review. The most relevant was the research by graphic designer O'Brien (2007) providing evidence in the form of statistical data based on 250 men and woman from over 35 countries. Her investigation included the emotions Anger, Joy, Fear, Love and Sadness, emotions which confirmed Plutchik's (2001) allocation of colours in relation to four emotions: Anger, Joy, Fear, Sadness. O'Brien's findings were part of the reason for the decision to only use these four emotions as a basis for the database.

5.2.4 Emotions as Silhouettes in Motion, The Online Survey

The intention of this part of the study is to provide the database users with a quick visual indicator of how well the particular expression is recognised in each of video clips. The output of the survey are data visualisations in the form of charts that provide information, and the scale of recognition points, the expressions in each video have received. The purpose of this visual information is to provide the database with a scale of communicative qualities for each of the video clips. As well as the opportunity to collect personal data, which an online survey provided, other parameters were incorporated in the study following a standard procedure that included respondents' background data: gender, age, affiliation and geographic location. The sample data was used as an exercise to develop a suitable method for using the statistics and data visualisation.

The amount of respondents that completed all of the online questionnaire was however too small (25 respondents) to draw any real conclusions regarding emotion recognition in the context of a socio-cultural perspective. The analysis in this section only serves as a standard procedural method of quantitative evaluation when the quantifiable parameters of the participants backgrounds are included.

5.2.4.1 Technical Description and Methods

The Expressive Movement Evaluation Survey (EMES) was developed in collaboration with a programmer (see section 2.2.6 *Collaboration and Collaborators*) using the open source platform *LimeSurvey* (2012) questionnaire and survey generator. This software was tailored to the requirements of the PTM in terms of its integration, structure, navigation, database and statistical data computations. The completed structure, together with associated video was uploaded and run from the research server at Gotland University, Visby, Sweden. Participants responded to the survey via an identifying token to allow them to access the questionnaire in several sessions, if needed. The very large volume of video material needed for participant review necessitated an "autosave" function for users, enabling them to break off and return to the survey at any time until completed.

The interactive online questionnaire was designed in three parts. The first page describes the study and invites participants to complete the questionnaire. Additional text explains that the data they supply is anonymised by the system. The second part requests participants to submit personal information on their gender, age, geographical origin and professional/educational status following a prepared list of questions. In the third part, participants are asked to select from the list, one emotion they most associate with the silhouette presented in a video clip (figure 5.4).

To answer the question about gender, selection was made via a radio button offering two choices. To provide their age, geographical location and occupational status, the respondents used drop-down menus from which they could choose answer options. The 76 video related questions asked participants to visually examine the video footage and to name the emotion they associated with the expressive movement presented as silhouettes in motion. The video session requested participants to watch 76 short videos, each 30 seconds long that represented four emotions: *Anger*, *Fear*, *Joy* and *Sadness*. Nineteen participants of different ages, backgrounds, and genders performed in these videos. For each video respondents could choose only one corresponding emotion from a multiple-choice table. These responses were scored using a value measured on a 5-point scale that represented how clearly they perceived the emotion with respect to their level of agreement where 1 = very difficult, 5 = very easy.

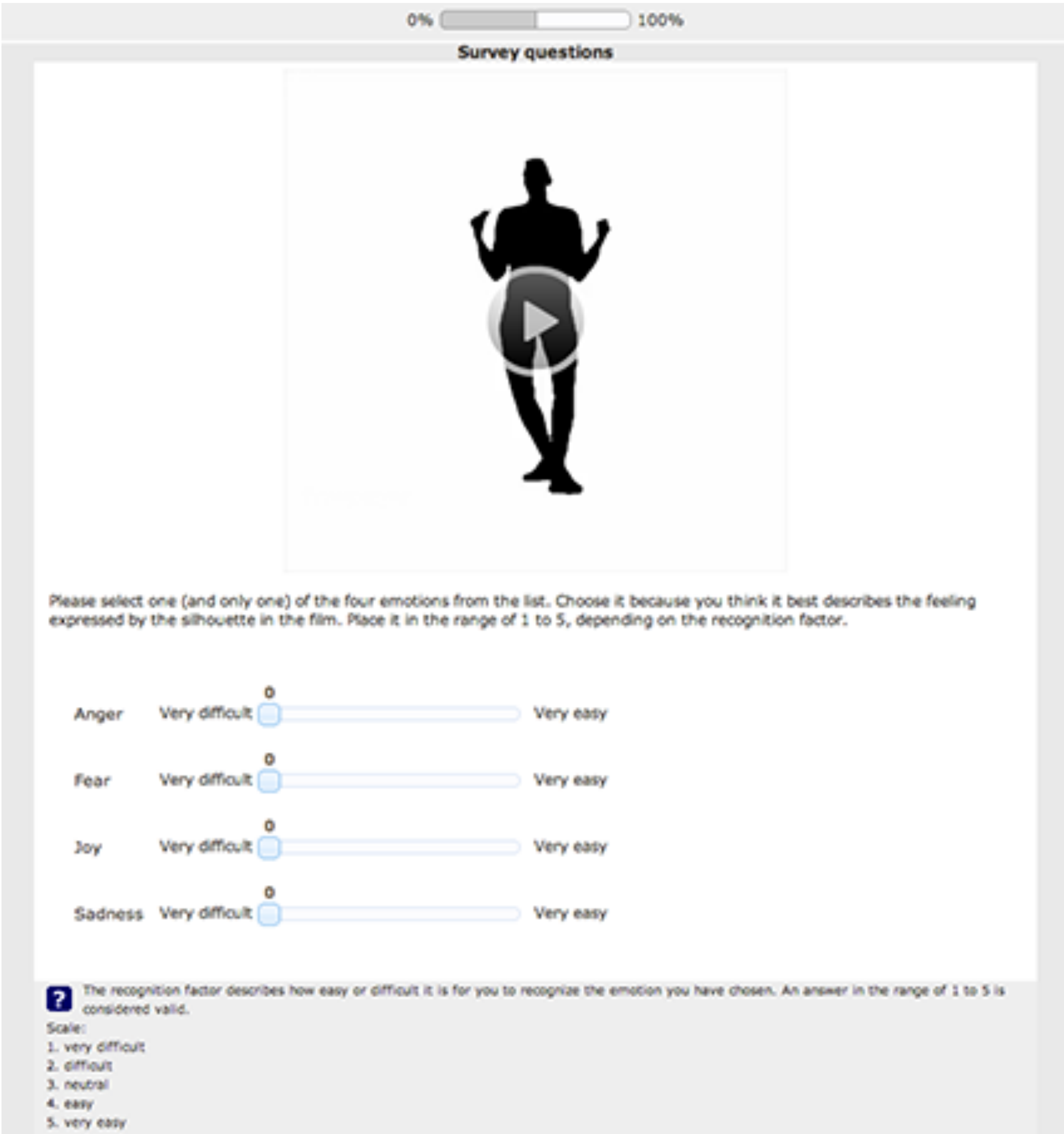


Figure 5.4 Video evaluation page in EMES, Hrynczenko, 2013.

The method, usually called forced choice, is a replication of the method used for facial, emotion recognition ability by Ekman and colleagues in the 1960s (Ekman, Friesen and Ellsworth, 1972) also evaluated by Russell *et al.* (Russell, 1994; Russell & Fernandez-Dols, 1997). Russell *et al.* (1994) proposed improved methods and multidimensional analysis (Russell and Dols, 1997) based on critiques of the forced choice method used by Ekman (1972). However, the methods used by both Ekman and Russell were replicated and compared by Schiano *et al.* (2000), showing a strikingly similar pattern in responses to all methods utilized. The selected questionnaire method is the forced choice following the Likert-scale, a decision made taking into consideration the possible prolonged time for the survey if additional open-ended questions were used.

The quantitative data received from the online survey is based on answers from 25 participants in which 63 respondents signed in, but only 25 completed all questions. The answers from the survey platform LimeSurvey (LimeSurvey Project Team and Schmitz, 2012) were exported to SPSS statistical software (IBM, 1968) for further data analysis as well as directly computed in LimeSurvey using the inbuilt statistical features and exported to Excel (Microsoft, 2011a) for further conversion necessary for the Circ*os* software (Krzywinski *et al.,* 2009) for data visualisation.

Several established methods in statistical analysis were used in order to provide qualitative data for visualisation of the movement recognition chart intended for the PTM database. These methods were used as an exercise in statistics and data visualisation and mainly based on associations (cultural/ geographic), groups (differences between recognised emotions) and predictions (on estimated higher sample size). Accordingly, to find the differences between emotions and to determine where these differences lie, the methods used are based on measures of central tendency and the analysis of variance (a one-way ANOVA).

5.2.4.2 Description of Participants and Recruitment Methods

The profile of the respondents is based on information received from answers to four personal questions such as: gender, age, geographical origin and professional/ educational status.

The answers were obligatory and could be chosen from lists that contain a standard set of answers for each of the five questions. The answer set was adapted from the questionnaire used in social science containing two radio buttons for gender: female, male. For the question on age, a drop-down list that included age ranges of four years, for example 15 to 19, 20 to 24. For the question on geographical origin, one answer could be chosen from the list of regions and sub regions according to the United Nations geoscheme. In order to answer the question on professional/educational status the respondents first of all needed to choose an answer selecting one of two radio buttons: 'student' or 'professional', and second, to choose one answer from a list that contained 72 different combinations of occupational/study alternatives.

The respondents of the online survey represent performance art, computer science, design/animation, art and game design, both students and researchers. Some of the participants were associates and friends with varied backgrounds. The majority of responses received came from students and professionals in the computer games and graphics sectors; 24.00%, followed by professionals in the area of science and research; 12.00% and from the area of education and training; 12.00%, see figure 5.5.

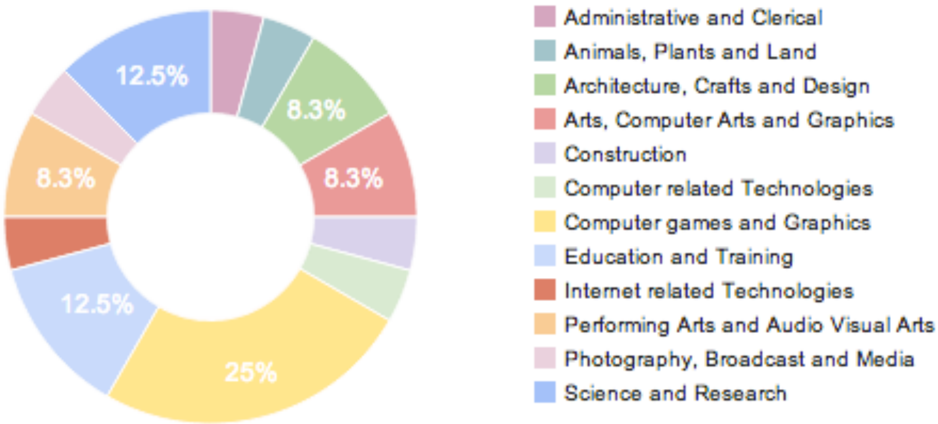


Figure 5.5 Chart, Survey of participants' occupation, Hrynczenko, 2013.

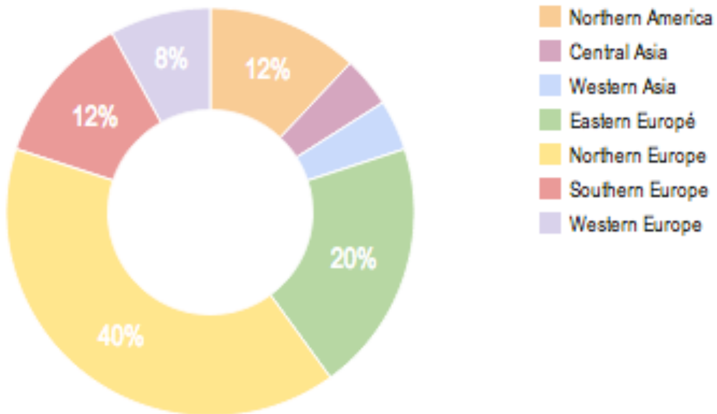


Figure 5.6 Chart, Survey of participants' geographic area, Hrynczenko, 2013.

Geographical distribution of the respondents indicates the largest number of participants are from Europe, with 40% from Northern Europe, 20% from Eastern Europe, 12% from Southern Europe and 8% from Western Europe; followed by 12% from North America, 4% Central Asia and 4% Western Asia (figure 5.6). The gender of participants is almost equally distributed; 52% females and 48% males.

All groups were contacted initially via email, followed by a diversified system of face-to-face recruiting at the University of Dundee, Scotland and Gotland University, Sweden, as well as during the workshops, conferences and through social on-line networks. Of the 100 individuals contacted in this process, 54 persons gave a positive response, 35 attempted the online survey and 25 fully completed the five personal questions and evaluation of 76 videos. These 25 qualified answers provided sufficient material to establish the basis for statistical analysis of rigid-body emotive movement recognition.

5.2.4.3 Analysis According to Respondents Personal Data

This part of the evaluation refers to the respondents' background data. The evaluation is used purely as training in statistical methods in terms of assessing data significance. The data collected is used for the exploration of data visualisation techniques. Except for gender, the number of participants in the remaining groups was unequally distributed due to low sample sizes, which prompted use of the Shapiro-Wilk's (1965) test. This type of test is usually used to determine whether the sample group was normally distributed. The Shapiro-Wilk's test estimates a samples normality, i.e. the significance of collected data, by calculating the probability in order to find out if the sample data are not significantly different from a normal population, which is positive, or if the sample data are significantly different which is negative. In the first case, probabilities (p) > 0.05 indicate that the data are normal. In the second case, the sample data are significantly different from a normal population when $p < 0.05$ indicating that the data are not normal and not significant for statistical calculations.

The results of the Shapiro-Wilk's test indicate that the point scores were normally distributed for both males and females ($p > .05$), while a comparison between total score versus age was not normally distributed for all groups with ($p < .05$) and therefore not investigated further. However, the mean difference in scores between age and gender within the sample was used for orientation purposes. Results for some of the participants occupation groups were not normally distributed showing ($p < .05$). Yet, analysis for the groups with normal distribution was used in order to estimate differences between the most represented working groups. Results based on Mean are presented in table 3 and the chart in figure 5.7. Mean (Average) - measures the central tendency and is the sum of total points in each of the groups divided by the amount of participants in the specific group.

Table 3 Emotion recognition according to participants' occupation based on Mean.

Work area	Anger	Fear	Joy	Sadness	Total points
Education and Training	78.5	50	76	60.7	66.3
Performing Arts and Audio Visual Arts	75.5	68	78.5	60.5	70.625
Science and Research	71	41	55	35.5	50.625
Architecture, Crafts and Design	78.5	65.5	76	64.5	71.125
Arts, Computer Arts and Graphics	69	50	74	55.5	62.125
Computer games and Graphics	78.5	63	78.5	65	71.25

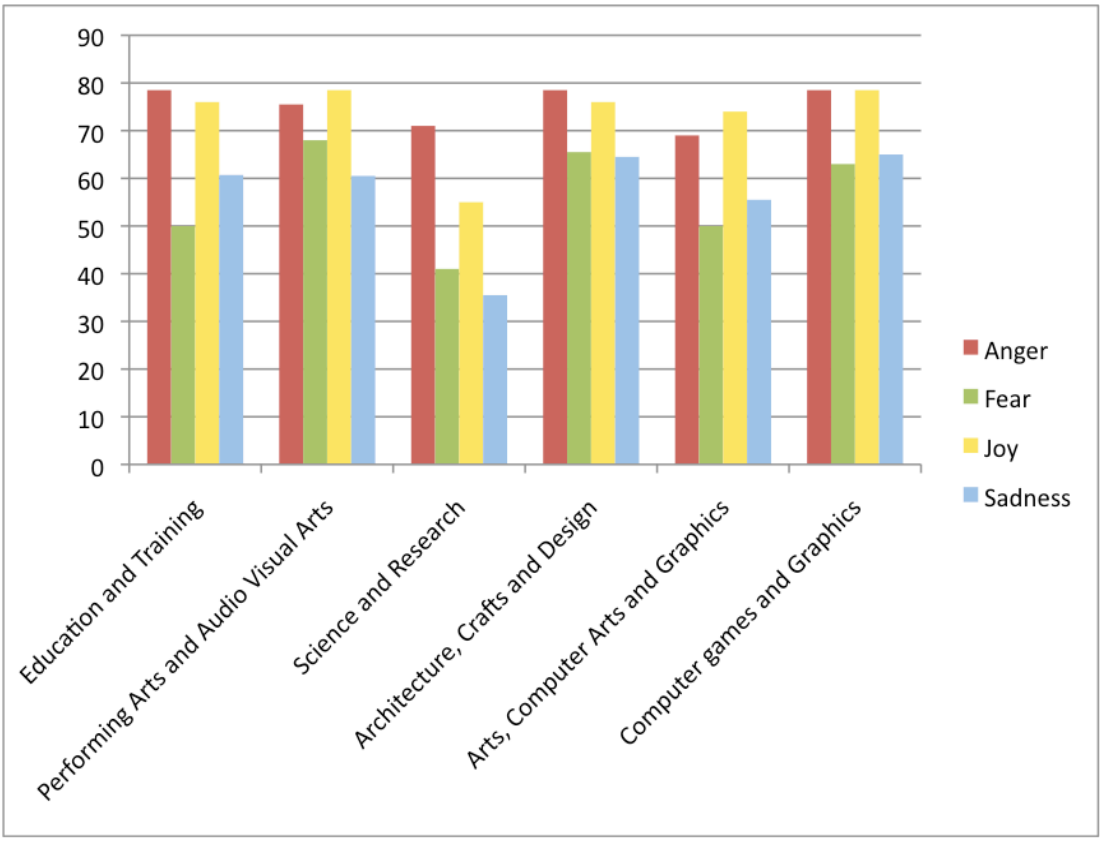


Figure 5.7 Chart, Emotion recognition according to participants' occupation, Hrynczenko 2013.

In order to determine the total recognition points for each working group the Mean of all the results was calculated as presented in table 3 and in the column *Total points*. The results show that the working group; Computer Games and Graphics has the best recognition scores for all four emotions with 71.25 points followed by Architecture, Crafts and Design with 71.125 and Performing Arts and Audio Visual Arts with 70.625. These results indicate that there are minimal differences among these three groups. Surprisingly the Computer Games and Graphics group is leading the recognition score indicating high sensitivity for movement perception among participants in this group.

The groups Education and Training with points 66.6 and Arts, Computer Arts and Graphics with 62.125 points show small differences in comparison to the three previous groups. However, there is a large difference in recognition points between all previous groups and the Science and Research group with 50.625 points, pointing at low movement recognition for participants of this group of respondents. Figure 5.8 illustrates the data from table 3 *Emotion recognition according to occupation area based on Mean.*

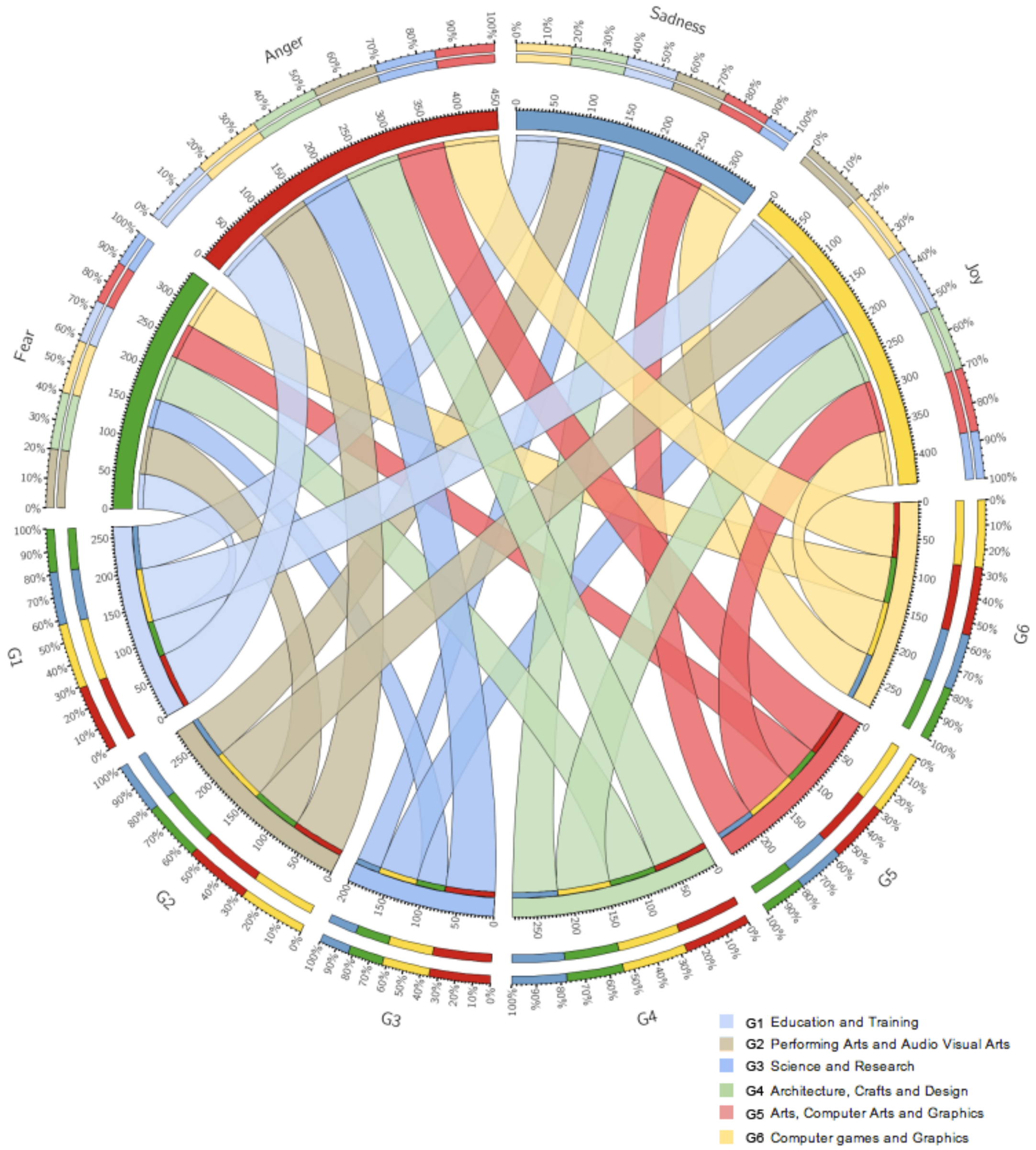


Figure 5.8 Diagram for recognition factor according to participants' occupation area, Hrynczenko, 2013

The relationship between emotion recognition points and gender is represented in table 4 showing a difference in movement recognition between female and male survey participants. The results point towards a tendency for males have better expressive movement recognition for all emotions than the female participants. However, the recognition points are unevenly distributed with regard to differences among emotions

Table 4 Emotion recognition according to gender.

	Anger	Fear	Joy	Sadness
Female	66.07	51.46	70.15	54.84
Male	73.16	53.08	75.16	55.83

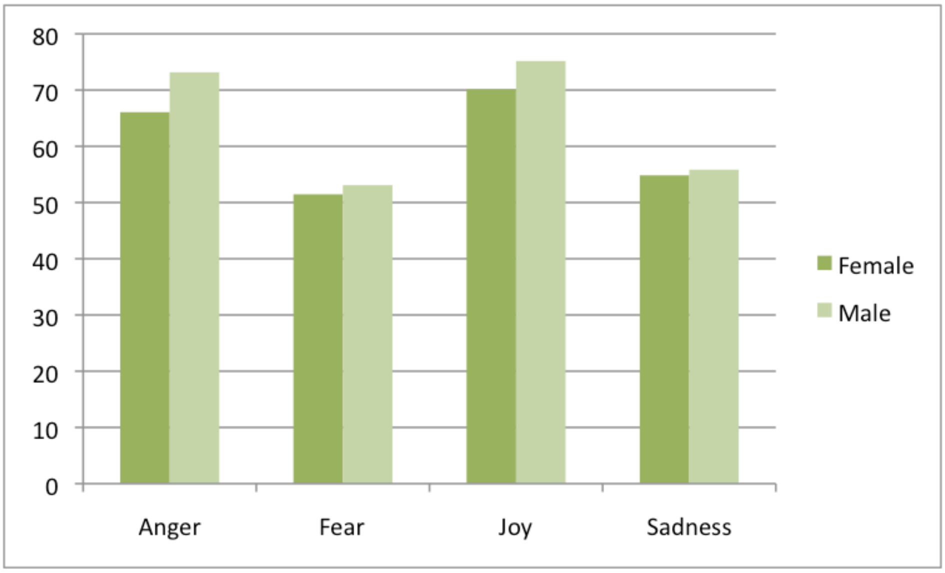


Figure 5.9 Emotion recognition chart according to gender, data from table 14, Hrynczenko, 2012.

Emotions such as Fear and Sadness have almost equal average recognition errors for all participants of the survey. These two have on the average less recognition points among all participants of the survey, which denotes the variety of expressions for these two emotions. In summary, the results of the survey have indicated differences in expressive movement recognition between female and male participants with males having a higher recognition score.

The analysis of the survey data regarding the occupation areas has shown that the Computer Games and Graphics group received a good emotion recognition score compared with the Science and Research group that have the lowest number of recognition points. The Computer Games and Graphics group is 95% male, while the Science and Research group is 90% female. The gamers are accustomed to reading movements on screen on a daily basis, with other participating researchers not necessarily having the same familiarity, coming from a variety of different disciplines and backgrounds. Therefore, these factors were not taken into consideration when comparing the results between these groups. However, this finding suggests that the participants' experience or time spent on screen-based activities, as part of their occupation should ideally be taken into consideration in this type of survey.

Total scores versus participants’ geographical region analysis were omitted based on unequal distribution among the groups where Northern Europe was overrepresented.

5.2.4.4 Emotion Recognition Analysis According to Each of Video Clips

Results for all 76 videos were collated and analysed according to four emotions: Anger, Fear, Joy and Sadness with the purpose to establish an emotion recognition factor for each of video clips represented in the PTM database and the expressiveness of each actor. In other words, the aim of this process was a visualisation of the differences of the actors’ expressiveness and possible expression similarities across emotions, in order to assess the usability of the video clips.

For evaluation of the video clips, a triangulation method was used based on feedback from 25 respondents of an online survey.

The statistical measure of central tendency was used based on the sum and mean of the score points for each of the 76 videos, where each emotion had four possible interpretations. The average was determined based on a scale of 1-5 wherein each video was analysed according to the generated set of model answers where 0 corresponds to a missing vote, i.e. no recognition, and a scale of 1 to 5 corresponds to an emotion recognition factor from Very Difficult to Very Easy.

Measures of central tendency are statistical methods that attempt to find the most common or central position in a data set, therefore, this method was used to summarise the data within the set.

Table 5 represents statistical data for video 019_anger where the statistical data results were based on the following parameters:

1) Sum of points - represents the number of points assigned by 25 respondents.
2) Standard deviation - shows how much variation exists from the expected value of 125, e.g. if all 25 respondents voted for Anger with a recognition factor of 5 points.
3) Mean (Average) - measures the central tendency and is the sum of total points divided by 25 (number of respondents).
4) Minimum - is smallest amount of points received from the respondent.

5) 1st quartile (Q1) - describes score of one quarter of the values that fall below the median in the distribution of scores arranged in ascending order.
6) Median value - is the "middle" value in the list of 25 points provided by respondents.
7) 3rd quartile (Q3) - describes the score of one quarter of the values that fall above the median in the distribution of scores arranged in ascending order.

Table 5 Results for central tendency for video 019_ anger.

019_anger	Recognition as Anger	Recognition as Fear	Recognition as Joy	Recognition as Sadness
Sum	120	0	0	0
Standard deviation	0.49	0	0	0
Average	4.8	0	0	0
Minimum	3	0	0	0
1st quartile (Q1)	5	0	0	0
Median value	5	0	0	0
3rd quartile (Q3)	5	0	0	0
Maximum	5	0	0	0

Minimum, Maximum, Q1 and Q3 allow measurement of the distribution of scores along a continuum providing insights to answers based on a 1-5 point-scale.
The calculations in table 5 for video clip 019_anger shows which emotion the respondents recognise in the silhouettes' expressive movement and how confident they feel about this recognition. Similarly, in table 6 for video clip 012_anger the recognition factor is distributed between the four possible answers.

Table 6 Result for central tendency for 012_ anger.

012_anger	Recognition as Anger	Recognition as Fear	Recognition as Joy	Recognition as Sadness
Sum	85	8	1	3
Standard deviation	1.88	0.88	0.2	0.59
Average	3.4	0.32	0.04	0.12
Minimum	0	0	0	0
1st quartile (Q1)	2.5	0	0	0
Median value	4	0	0	0
3rd quartile (Q3)	5	0	0	0
Maximum	5	3	1	3

The mean of all responses for each emotion presented in figures, 5.10, 5.11, 5,12 and 5.13 was calculated in order to find a central tendency of emotion recognition on a scale of 0 to 5.

These calculations presented in corresponding tables with the same number are used to find which expressive movements and gestures were easy or difficult to recognise and to estimate which emotion has the best recognition factor.

Table 7 Results of recognition factor for emotion anger.

	Recognition as Anger	Recognition as Fear	Recognition as Joy	Recognition as Sadness
001_anger	2.16	0.32	0.12	0.04
002_anger	4	0.12	0.08	0
003_anger	4.88	0	0	0
004_anger	0.4	0.76	0	0.8
005_anger	3.16	0	0.24	0.04
006_anger	4.6	0	0.12	0
007_anger	4.6	0.16	0	0
008_anger	3.48	0.08	0	0
009_anger	4.56	0	0	0
010_anger	3.72	0	0.12	0
011_anger	1.76	1.64	0	0
012_anger	3.4	0.32	0.04	0.12
013_anger	3.52	0	0.24	0
014_anger	4.44	0.12	0	0
015_anger	2.08	0.2	0.24	0.28
016_anger	4.52	0	0	0
017_anger	4.6	0	0.16	0
018_anger	4.8	0	0	0
019_anger	4.8	0	0	0
Sum	69.48	3.72	1.36	1.28
Average	3.656842105	0.195789474	0.065263158	0.067368421

The results in this table are also presented in figure 4.34 in section 4.5.3 *Visual Interpretation of Survey Data* as a demonstration of the method. The diagram presented in figure 5.10 the diagram corresponds to the results from table 7.

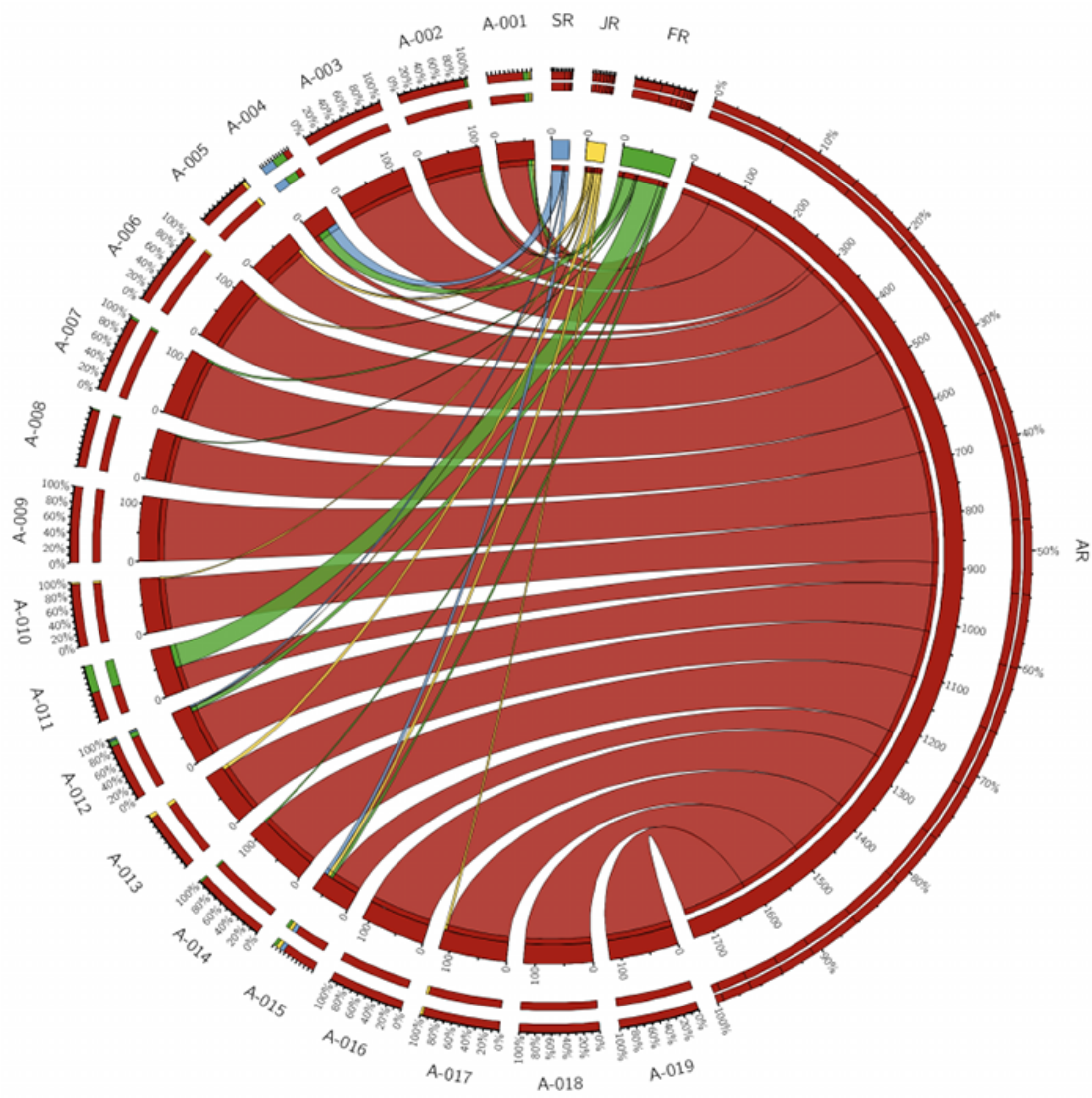


Figure 5.10 Relational diagram for recognition factor of anger, data from table 7, Hrynczenko, 2013.

Diagram (figure 5.10) uses the following abbreviations:
A-001 - video file name 001_anger.

Colours corresponding to their emotion recognition factor:

AR - anger recognition (red)
FR - fear recognition (green)
JR - joy recognition (yellow)
SR - sadness recognition (blue)

In the diagram above, the colours green, yellow and blue represent recognition errors. For example movements in video A-011 is also recognised as fear and in A-004 both as fear and sadness, which is indicated by the colours green and blue that correspond to these emotions

Table 8 illustrates recognition factor results for the emotion fear and are visualised in the corresponding graph (figure 5.11). From this data it is apparent that fear is often misinterpreted as sadness, a conclusion based on the sum of error recognition points for sadness showing 11.48 points.

Table 8 Results of recognition factor for emotion fear.

	Recognition as Anger	Recognition as Fear	Recognition as Joy	Recognition as Sadness
001_fear	0	1.65	0.12	0.6
002_fear	0.16	3.12	0	0.16
003_fear	0.2	1.96	0	0.16
004_fear	0.32	1.44	0.12	0.36
005_fear	0.32	1.44	0.12	0.36
006_fear	0	4.76	0	0
007_fear	0.08	4.04	0	0.12
008_fear	0	3.12	0.12	0
009_fear	0	4.72	0	0
010_fear	0.84	2.64	0.08	0
011_fear	0	1.01	0	0
012_fear	0.36	0.84	0	2.08
013_fear	0.08	1.4	0	0.64
014_fear	0	4.28	0	0.08
015_fear	0	1.8	0	1.48
016_fear	0	0.96	0	2.6
017_fear	0	4.08	0	0
018_fear	0	0.96	0	2.84
019_fear	0	4.56	0	0
Sum	2.36	48.78	0.56	11.48
Average	0.124210526	2.567368421	0.023157895	0.604210526

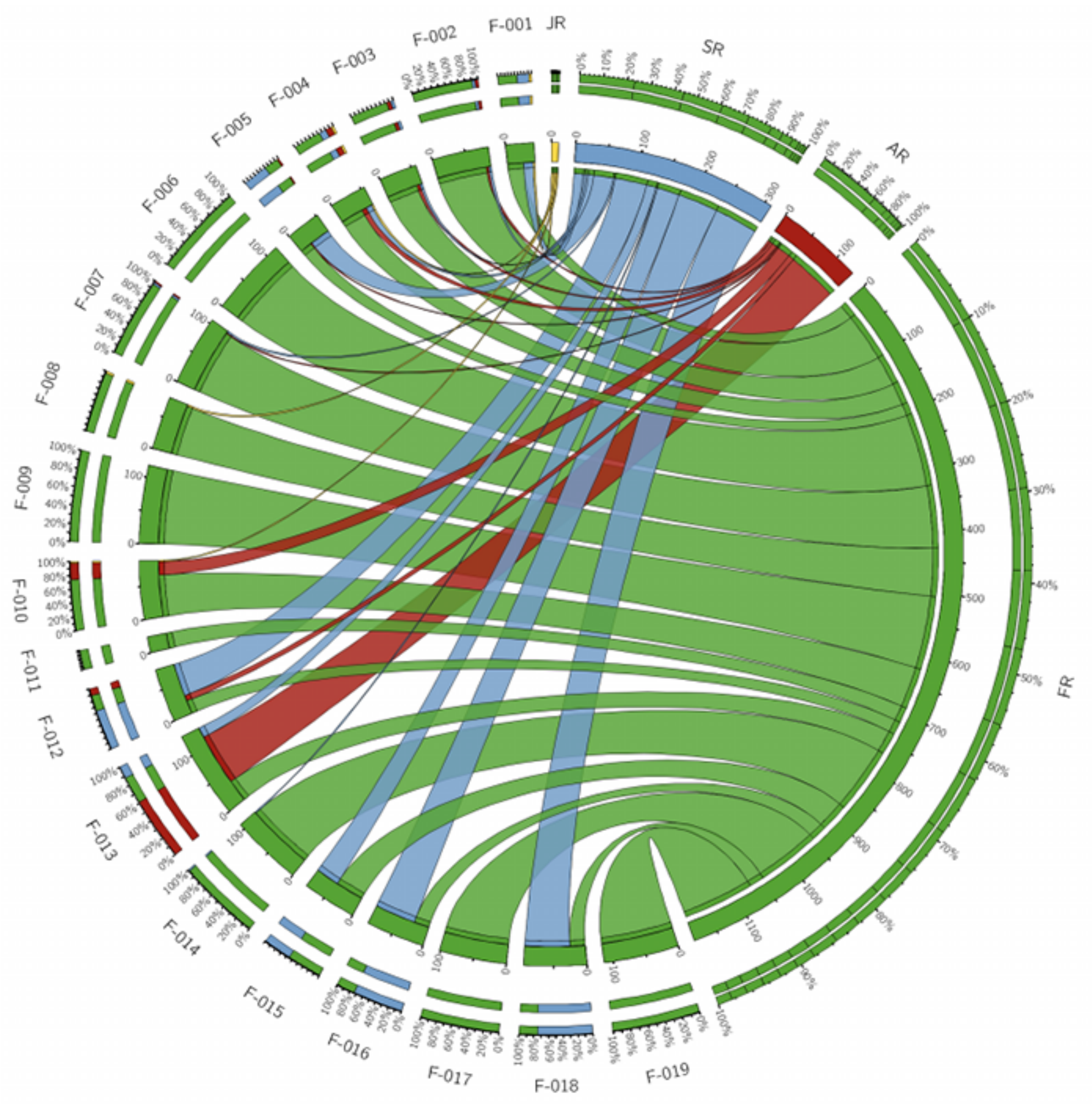


Figure 5.11 Relational diagram for recognition factor of fear, data from table 8, Hrynczenko, 2013.

Diagram (figure 5.11) uses the following abbreviations:
F-001 video file name 001_fear.

Colours corresponding to their emotion recognition factor:

AR - anger recognition (red)
FR - fear recognition (green)
JR - joy recognition (yellow)
SR - sadness recognition (blue)

The diagram above, based on the data in table 8 illustrates that besides sadness, fear is confused with anger mainly in two videos F-013 and F-010. Fear interpreted as sadness is most apparent in F-018, F-016, F-015 and F-012. A very small percentage of recognition error is visible in the group F-002 - F-004 and F-008.

Table 9 Results of recognition factor for emotion joy.

	Recognition as Anger	Recognition as Fear	Recognition as Joy	Recognition as Sadness
001_joy	0	0	4.96	0
002_joy	0.24	0	4.12	0
003_joy	0	0	4.56	0
004_joy	2.64	0	1.16	0
005_joy	0.12	0.16	0.28	1.16
006_joy	0	0	4.84	0
007_joy	0.2	0	4.4	0.12
008_joy	0.12	0.08	3.28	0
009_joy	0	0	4.84	0
010_joy	0.04	0	3.76	0
011_joy	0	0	4.6	0
012_joy	0	0	4.8	0
013_joy	0.04	0	3.44	0
014_joy	0	0	4.84	0
015_joy	0.12	0	3.84	0
016_joy	0.16	0.04	2.56	0.36
017_joy	0.08	0	4.64	0
018_joy	0.2	0	4.32	0
019_joy	0.28	0.08	3.32	0.24
Sum	4.24	0.36	72.56	1.88
Average	0.223157895	0.018947368	3.557894737	0.098947368

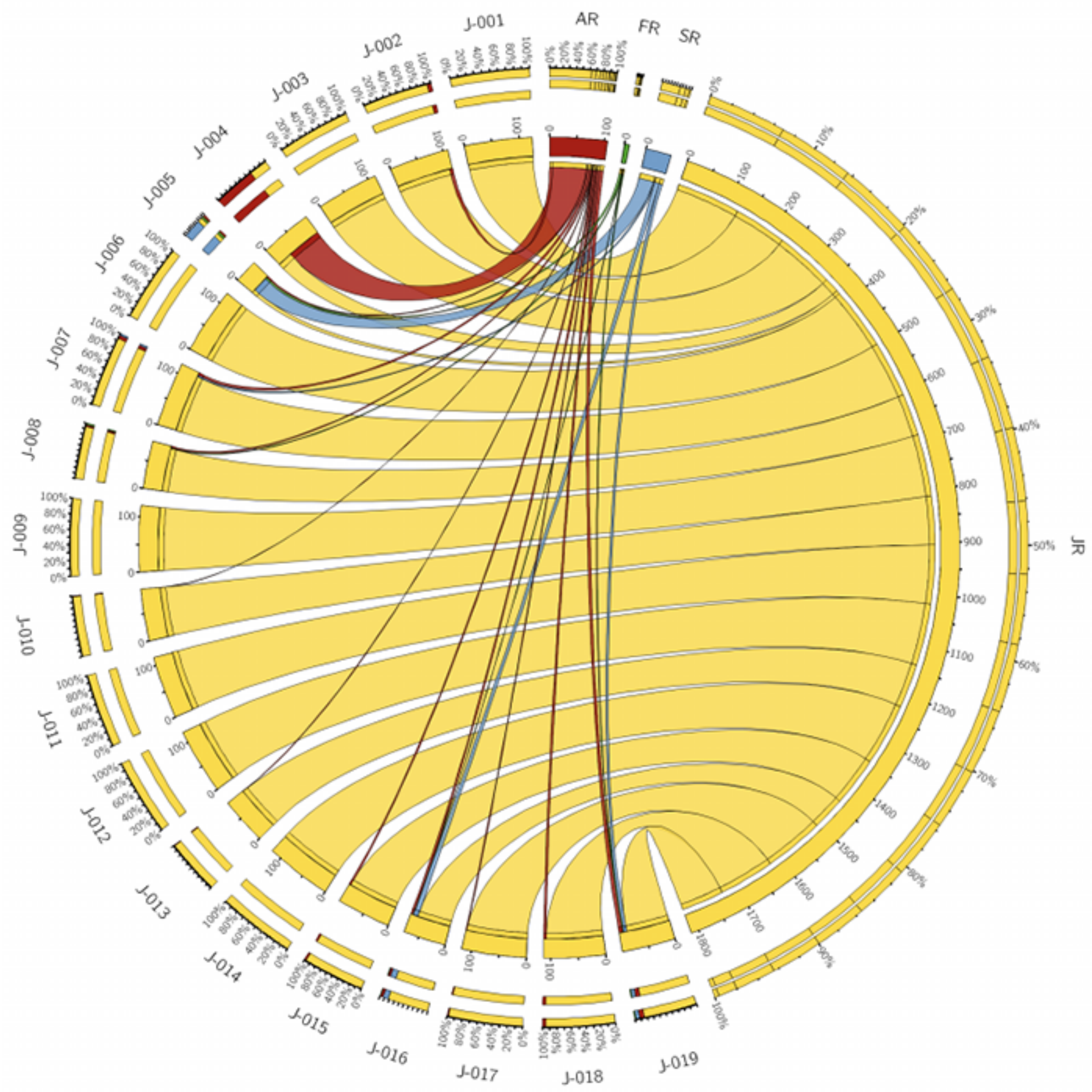


Figure 5.12 Relational diagram for recognition factor of joy, Data from table 9, Hrynczenko, 2013.

Diagram (figure 5.12) uses the following abbreviations:
J-001 video file name 001_joy.

Colours corresponding to their emotion recognition factor:

AR - anger recognition (red)
FR - fear recognition (green)
JR - joy recognition (yellow)
SR - sadness recognition (blue)

From the diagram above, based on the data in table 9 we can identify that two video, J-005 and J-004, show a high misinterpretation of the emotion joy. In the case of J-004 joy is interpreted as anger and in case of J-005 as sadness.

Table 10 Results of recognition factor for emotion sadness

	Recognition as Anger	Recognition as Fear	Recognition as Joy	Recognition as Sadness
001_sadness	0	1.04	0	1.96
002_sadness	0	0.2	0.36	1.44
003_sadness	0	0.56	0	2.32
004_sadness	0	0.28	0	3.64
005_sadness	0	0.52	0	3.32
006_sadness	0	0.12	0	3.64
007_sadness	0	1.08	0	1.88
008_sadness	0	0.24	0	3.76
009_sadness	0.16	0.12	0.08	2.28
010_sadness	0.04	0.28	0.28	2.32
011_sadness	0	0.56	0	2.52
012_sadness	0.08	0.96	0.12	1.64
013_sadness	0.04	0.32	0.08	2.16
014_sadness	0	0	0	4.68
015_sadness	0.08	0.16	0	3.6
016_sadness	0	0.2	0	3.96
017_sadness	0	0.08	0	3.48
018_sadness	0	0	0	4.4
019_sadness	0.56	0.04	0	2.32
Sum	0.96	6.76	0.92	55.32
Average	0.050526316	0.355789474	0.048421053	2.911578947

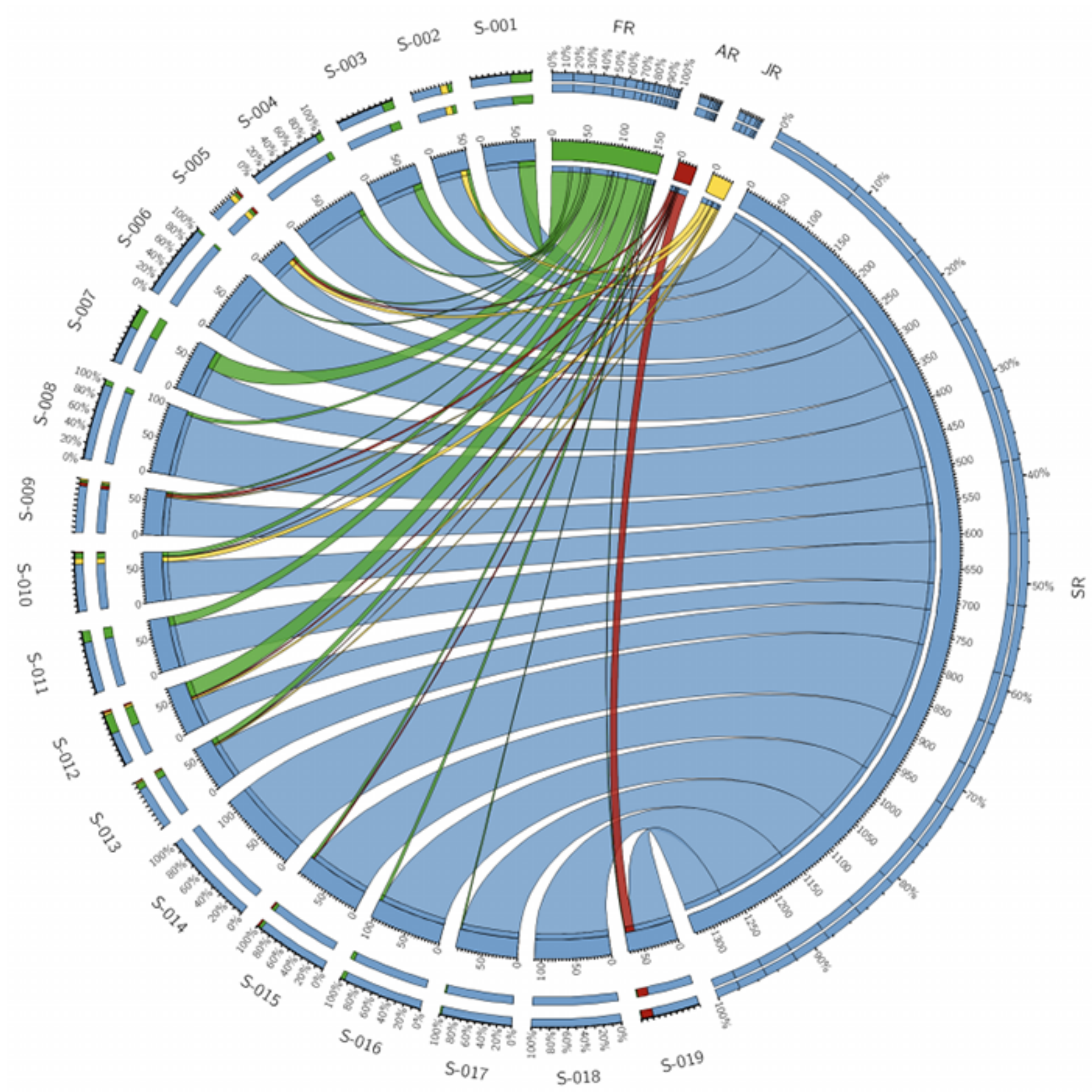


Figure 5.13 Results of recognition factor for emotion sadness, data from table 10, Hrynczenko, 2013.

Diagram (figure 5.13) uses the following abbreviations:
J-001 video file name 001_joy.

Colours corresponding to their emotion recognition factor:

AR - anger recognition (red)
FR - fear recognition (green)
JR - joy recognition (yellow)
SR - sadness recognition (blue)

As indicated in the diagram above, expressive movements of sadness are often seen as fear, a recognition error that corresponds to almost all the video material of sadness. In the case of S-019 sadness is misinterpreted as anger and in the case of S-002, S-005, S-010 and S-012 as joy to a small extent.

In order to establish differences and correlations in the interpretation of expressive movement between emotions, the average of all expressions in each video was calculated using the recognition factor between emotions, i.e. the results from the previous four tables were calculated and compared using central tendencies such as the mean value. Data are presented in table 11 and visualised by the diagram in figure 5.14.

Table 11 Results based on mean for recognition factor for all emotions.

	Recognition as Anger	Recognition as Fear	Recognition as Joy	Recognition as Sadness
Anger	3.66	0.2	0.07	0.07
Fear	0.12	2.57	0.02	0.6
Joy	0.22	0.02	3.56	0.1
Sadness	0.05	0.36	0.05	2.91

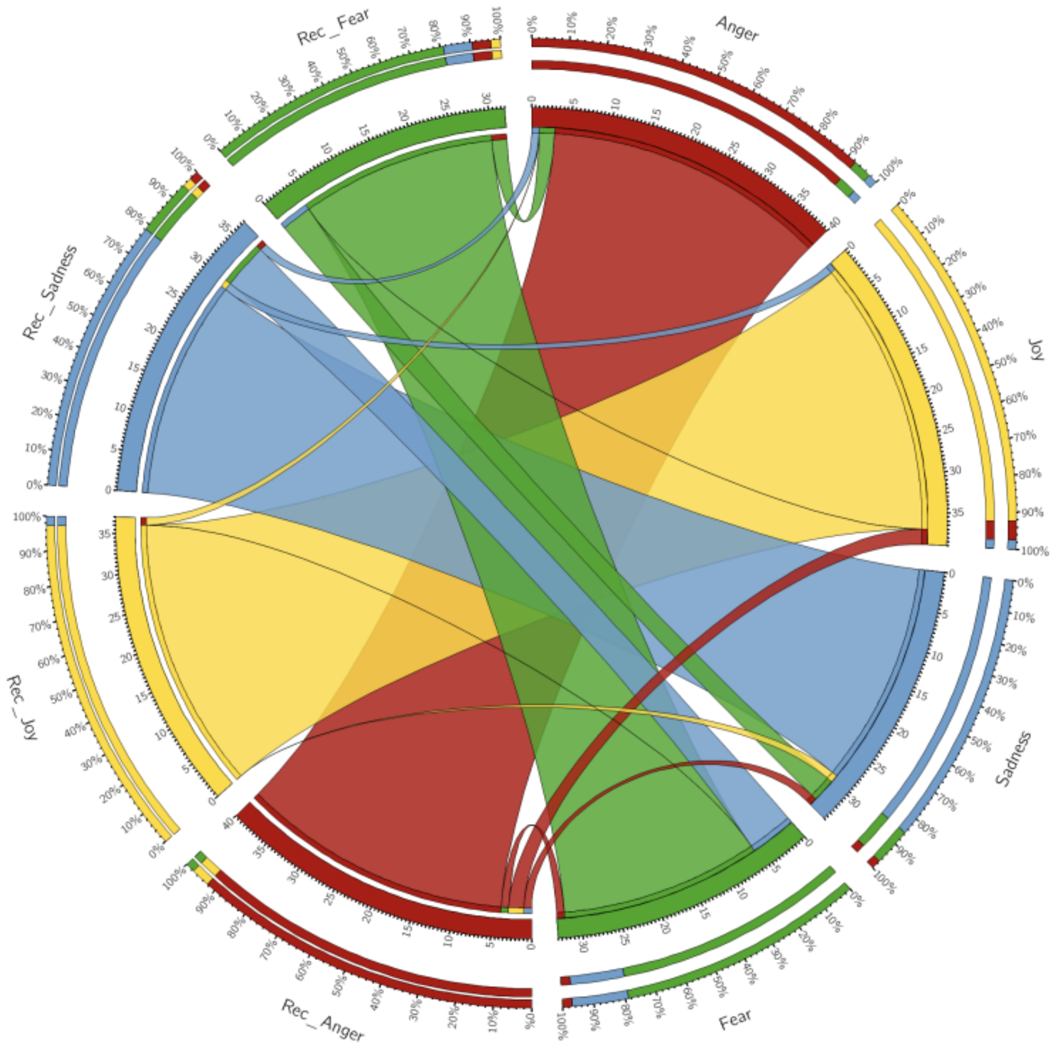


Figure 5.14 Diagram, based on table 11, recognition factor for all emotions, Hrynczenko, 2013.

The noteworthy tendency in the previous tables indicates that all four emotions represent a high point score for the recognised emotions. The results show that the emotions most easily recognisable were Anger and Joy. However, there are differences in recognition factors between the best and least recognised emotions.

In the analysis of the best recognition factor based on a scale of 0-5, Anger expressed as a whole body movement and gesture shows the highest percentage of correct answers with an average recognition factor 3.66. Joy shows a slightly lower average of recognition; 3.56, followed by sadness with 2.91 and lastly fear; 2.57. Considering the variety of movements and expressions grounded in the performers' movement characteristics it seems that Fear and Sadness are often misinterpreted.

In this case, Fear is perceived as Sadness, which is visible as 0.6 points of recognition error and sadness showing 0.3 points of misinterpretation of the emotive expressions as Fear. The visual analysis of movements shows that emotive expressions of Fear are sometimes similar to movements that express sadness.
In order to find recognition percentages for each emotion, central tendency measurements were performed. The measurements are based on the mean of the total number of points scored where the total mean of 100% recognition is equal to 95 points.

Table 12 Result per cent for each emotion according to score value.

	Anger	Fear	Joy	Sadness
Mean %	73.13%	54.98%	76.37%	58.23%

The results in table 12 show that joy has the highest score with M = 76%, followed by anger with M = 73%, sadness M = 58% and fear M = 55 %. In summary, joy and anger were the most accurately matched expressions with the highest recognition scores. There are two possible reasons for this, the first due to the intensity of expressions used by performers and socio-cultural factors as these basic emotions are often expressed in relation to other emotions and therefore more externally expressed and easily recognisable. In contrast, the expressive movements of fear and sadness are more internally expressed, where expressions have more personal characteristics and therefore it is sometimes more difficult to differentiate.

The results suggest that, despite the differences in the actors' interpretations of the emotions across the video clips, the respondents share a common recognition of the emotions in which some of the emotions, based on the nature of the expression, are easier to recognise than others. Error data revealed that fear is often confused with sadness or anger, while sadness is confused with fear. Comparing these findings with the cognitive science research on emotions in facial expressions (Schiano *et al.*, 2000) the results show the same differences between joy (Happiness) and fear (M = 99%) and the lowest value for fear (M = 82%) which closely replicates the results of Ekman and colleagues (Fridlund, Ekman and Oster, 1987)). At the same time, comparing the results to facial expression, expressive movement indicates a lower recognition percentage.

The summarised output of the survey based on correct answers on the emotion recognition factor forms a basis for further analysis. In this example, the aim is to estimate the differences in recognition scores among emotions.
A one-way ANOVA was conducted to examine whether there were statistically meaningful differences among the four emotions based on the sum of the score points for each emotion. If the p-value is less than or equal to 0.05 (5%), the result is deemed statistically significant, i.e. there is a significant relationship between the variables. The results of ANOVA revealed statistically noteworthy differences among the four groups of emotions F =14, 86, df = 3, p = .000. Where F represents the ratio between two degrees of freedom (df), the degrees of freedom of the numerator (among-group variance) and degrees of freedom of the denominator (within-group variance) known as sig. or p-value. P-value is a probability or statistical significance value, which ranges from 0-1.

The test shows that differences for Anger are equal with Joy in relation to Fear and Sadness, where a difference between Joy and Anger and between Fear and Sadness was not statistically significant.

The summary of the recognition factor based on the correct answers was the basis for further analysis in order to estimate, this time, the differences in recognition scores among emotions. In order to obtain statistical significance in differences among the emotions analysed, the statistical method for the analysis of variance (ANOVA) was again used.

The ANOVAs analysis was conducted based on the way the results in each group differ internally versus the difference between all groups. ANOVA calculates the mean for each of the four emotions' recognition score (anger, fear, joy, sadness) based on the Group Means. The second calculation step was to use the calculations of the mean for all the emotion groups combined. Within each emotion group, the total deviation of each individual points score from the Group Mean was analysed, i.e. the Within Group Variation. Next, a calculation of the deviation of each Group Mean from the Overall Mean was carried out, known as the Between Group Variation. Finally, based on these calculations, ANOVA produces the F statistic, which is the ratio of the Between Group Variation to the Within Group Variation. The analysis of variance is based on the rule that if the Between Group Variation is significantly greater than the Within Group Variation, then it is likely that there is a statistically significant difference between the groups. (Sim and Reid, 1999)

Post-hoc Scheffé tests revealed statistically noteworthy differences between the emotions, specifically between Fear (M =52.24, SD = 15.134), and Joy (M = 72.56, SD = 9.743) as well as between Anger (M = 69.48, SD= 12.923) and Sadness (M = 55.32, SD = 14.029). Emotion recognition for Joy and Anger reports indicates a notably higher score compared to Fear and Sadness. There were no significant differences between the recognition scores in Joy and Anger and between Fear and Sadness.

Table 13 Result of ANOVA analysis.

	Anger	Fear	Joy	Sadness
Mean	69.48	52.24	72.56	55.32
SD	12.923	15.134	9.743	14.029

5.2.4.5 Emotion Recognition Analysis According to Each Actor

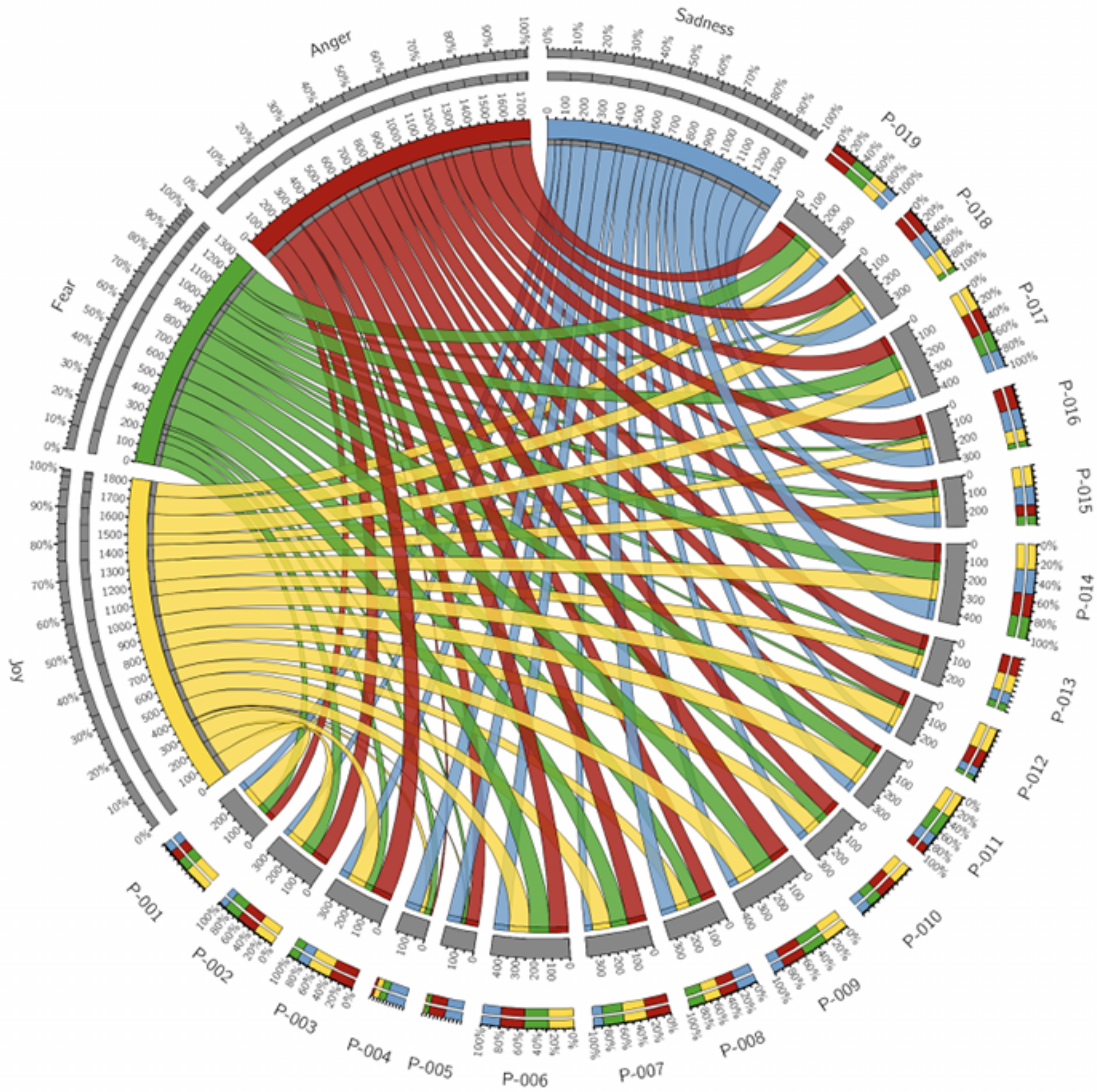


Figure 5.15 Relational diagram for recognition factor for 4 emotions, data from table 14, Hrynczenko, 2013.

Data contained in a table 14 are visualized in figure 5.15.

P-001 abbreviation corresponds to all four video files of one performer, in this case performer 001. P-001 = (001_anger + 001_fear + 001_joy + 001_sadness).

Colours corresponding to their emotion recognition factor:

red = anger
green = fear
yellow = joy
blue = sadness

The diagram above illustrates both the total recognition points for each emotion as well as the distribution of recognition points for each evaluated video and each emotion.

For example when considering the coloured stripes placed close to the actor's number, actor 001 has received most recognition points for the expressive movement of joy (yellow stripe) while for performer 004 most of their expressions were mistaken as sadness. The best-recognised expressions are visible as equally divided four colour stripes and apply to actors P-006, P-014 and P-017.

Table 14 Data for recognition points for all performers and all four emotions.

	Anger	Fear	Joy	Sadness
P-001	54	62	124	49
P-002	100	78	103	36
P-003	122	49	114	58
P-004	10	36	29	91
P-005	79	19	7	83
P-006	115	119	121	91
P-007	115	101	110	47
P-008	87	78	82	94
P-009	114	118	121	57
P-010	93	66	94	58
P-011	44	108	115	63
P-012	85	21	120	41
P-013	88	35	86	54
P-014	111	107	121	117
P-015	52	45	96	90
P-016	113	24	64	99
P-017	115	102	116	87
P-018	120	24	108	110
P-019	120	114	83	58

The data from Table 14 presented in figure 5.15 was used to create another type of visualisation that could be implemented in the database with the purpose of making the data more accessible for database users. The final result of the evaluation of each of the actors' expressiveness and gesture readability is visualised in figure 5.16. This visualisation was previously presented in section 4.5.4 *PTM, Information Visualisation* however, it was only described from its general association to the database and not from a quantitative evaluation perspective. The visualisation is repeated in this new context mainly since it is one of the main outputs of the online survey.

In the visualisation process, the outer circle from the chart as discussed above was used to complete the star chart in figure 5.16. The star chart, also known as a spider or radar chart is a graphical method of displaying a summary of multiple data series where all

data values are shown at once. In this case the recognition points for each of the four emotions for each of the 19 actors. The individual axes that start from the same point represent each of the actors. On the end of each axis, the silhouette of the particular actor was added to make easy for database users to recognise each of them. A line connects the data values for each of the 19 axes that create the star chart. Each star represents each of the emotions: red for anger, green for fear, yellow for joy and blue for sadness. An indication of how well the four emotions were performed by the actors, as recognised by the survey respondents, can be gained by tracing the coloured lines comprising the four stars . By looking at all the axis, the information indicates how the actor's performance of each emotion compares relative to the other actors.
This visual approach makes it possible to compare the aggregate data values. The data from the table columns (the stars) and table rows (the axis) is plotted according to the scores of the recognised emotion for each of the actors numbered from P-001 to P-019.

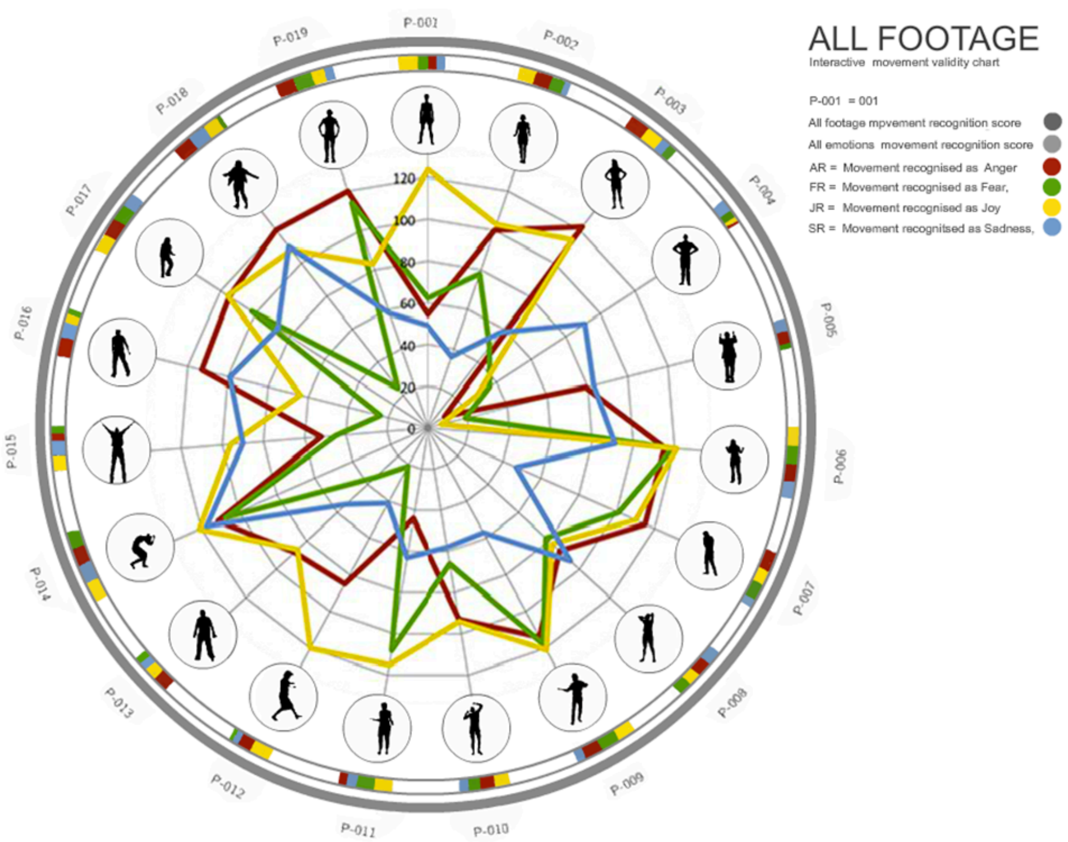


Figure 5.16 Evaluation results for all emotions and footage, data from table 14, Hrynczenko, 2013.

5.2.4.6 Summary

The results of the expressiveness of emotions and gesture readability evaluations for each actor and video clip were transferred to the star chart and added to the database together with four circular charts for each emotion and video clip. The graphs became part of the final database providing additional visual material for future expressive movement analysis. Additionally, the visual data of movement patterns and the timeline based chronographic charts were added for each of video clip as a part of the PTM database, providing a useful tool for future studies. This same feature supported the next step of the study, namely, the triangulation process.

Overall, the 25 online survey participants have shown a complex array of expressive movement associations with varying degrees of emotion recognition capabilities, performed across 76 tasks. The results indicate that despite the absence of facial expressions, the recognition of expressions in the video clips in percentage terms was almost equal for Anger (69.48) and Joy (72.56), and with the similar distribution for Fear: (52.24), and Sadness: (55.32). The diversity of expression readability is high across all examined video clips. Based on these differences across expressions, each of the 76 video clips reviewed is assigned a reliability indicator and accessible within the database.

Comparing these findings with the results of facial emotion recognition research by Fridlund, Ekman and Oster (1987), the observation is made that the same recognition distribution between these two groups demonstrates that the recognition factor for facial expression is higher than the recognition factor for whole body expressiveness. Several possible reasons may contribute to the differences but primarily because the size of the sample group in the expressive movement test is much smaller than the sample groups for facial expression recognition, creating an unequal basis for comparison. Practical limitations such as the availability of participants and the time consuming survey have an impact on the final output. Another inconsistency between tests is that those conducted on facial expressions are based on still images, i.e. photographs of human faces and conducted in other tests in paper format. However, the expressive movement test is based on motion in the digital environment, demanding from respondents higher concentration and focus. The online survey had 60 respondents, however only 25 completed the survey in full. In order to mitigate the issues of small sample groups and incomplete surveys in the future, some form of token recompense could be offered as a reward. Alternatively, the survey could be gamified providing game reward points as remuneration. An interesting aspect for future research would be tests using the same silhouettes in a real life environment, in order to evaluate if the same expressive movements would be more readily recognised compared to the pre-recorded movement material in a digital format. This procedure could also provide an indicator for the differences between real life and digital expressive movement perception.

Despite the fact that the survey was carried out with a small sample group, the noteworthy part of this study is finding that Joy and Anger have the best recognition scores, pointing at similar results in previous research summarised by Fridlund, Ekman and Oster (1987). Regarding the future use of the database with optical movement recognition interfaces such as Kinect (Microsoft, 2010), these two emotional expressions as whole body movement should be investigated more closely, which partly is continued in the next section of this research where a relational model of generic expressions was investigated.

The group comparisons of 'mean' data provide a few interesting findings regarding movement recognition based on age, gender, occupation. One interesting finding reveals that in the tests respondents with a game design occupation have the best recognition scores of expressive movement. A possible underlying reason for this result could be this groups greater focus on movements on the screen. At the same time, this fact may also indicate that participants in this group develop a higher visual perception and emotional sensibility through screen-based experiences. Without any further corroborating evidence however, more research is needed on how embodied expressions are perceived in digital and real environments.

Regarding the future use of the database, as both as a tool for animation studies and in conjunction with motion sensing devices, all four emotional expressions: Anger, Fear, Joy and Sadness were examined in the next step of the research by mapping expressions with the highest number of recognition scores. This approach provided a grounding for the triangulation process intended to create visualisations of typical yet idealised postures for each of the four emotions. This idea developed further during the triangulation process in which Posture diagrams of Postures and Skeletons were created, providing a basis for the Periodic Table of Movements. Described in the next section, the triangulation process contains several steps and builds on results from the analysis of recognition scores.

5.2.4.7 Spatial and Visual Data Analysis

This section describes both spatial and visual analysis of expressive gestures and key postures based on all the content contained in the PTM, such as video, diagrams, plots, chronographic timelines, and interactive tools. On one hand, this approach shows the possibilities the database provides in terms of the use of visual assets for comparative studies. On the other, the output of this study provides a correlation table, the Periodic Table of Movements, a higher-level tool for character animation for games and gesture recognition in connection with sensing devices such as Kinect (Microsoft, 2010). The objective was to visualise correlations amongst expressions between four emotions in the circular chart of key postures where the correlations are presented as networks. In parallel, it is an examination and showcase of the database features and possibilities.

5.2.4.8 Methods and Technical Description

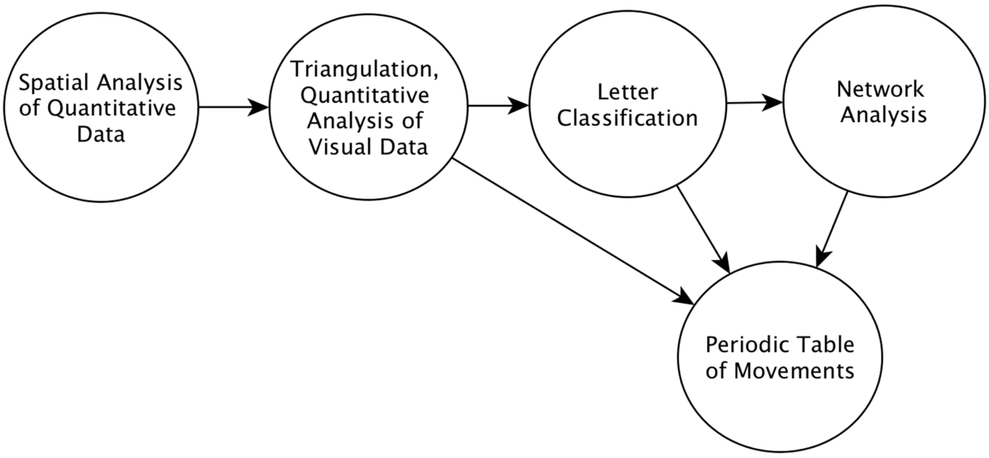


Figure 5.17 Diagram, Spatial and visual data analysis, Hrynczenko, 2013.

The methods employed in this study are both of a quantitative and qualitative nature, in which analyses of expressive movements are based on both measurements and triangulation of visual and quantitative data. Since the different parts of the study are correlated, each section contains a description of the applied methods and procedures used. The analysis of the results presented in all the sections are summarised and presented at the end. This is an iterative process whereby; the output of one section's analysis instigates the process of the next. To explain this process, a work flow diagram is provided in figure 5.18 and more specific diagrams are presented in the following sections.

5.2.4.9 Spatial Analysis, Kinematic Data for Visual Pattern Recognition

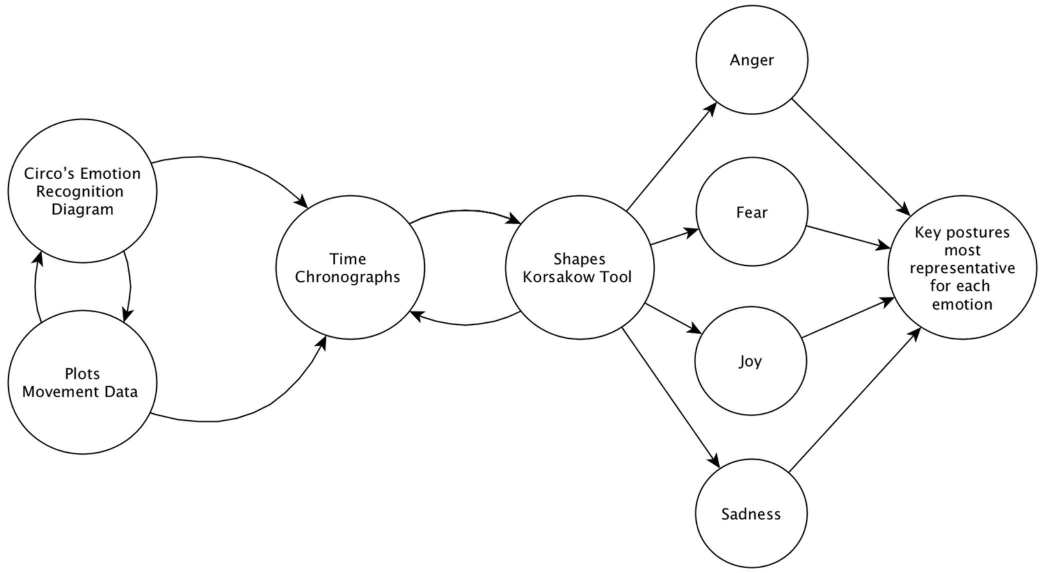
The aim of the spatial analysis was to distinguish movement patterns based on numerical kinematic data obtained from the analysis of the video material. The reason for this investigation was to provide graphic interpretations of movement characteristics specific for each video clip and emotion. Graphical interpretation has the advantage of allowing an effective visual overview of the quantitative data samples.

The kinematic numerical data received from the VideoAnalysi*s* program (Jensenius, 2007-2012) was used for visual pattern recognition together with the results of previous analysis from the survey and chronographic time series visualisations. The kinematic data from the video analysis describe the patterns of motion such as position, movement intensity, acceleration, direction, and velocity; thereby providing specific information for each video movement when converted to visual charts and plots. The numerical data received in text file format from the VideoAnalysi*s* software was extensive, containing 748 y-axis positions for each frame of video and 19 variables in the x-axis (i.e. 14,212 positions for each of the videos analysed). This extensive volume of data was therefore best suited for analysis using graphs and plots. To estimate the central tendency for all emotions separately, the average for each variable in the sample data from every video was calculated, sorted by each video and compared during the triangulation process.

Analysis of movement in each frame of video footage provided numerical data information on Time; x, y position; x, y velocity and *QoM*. The information was visualised in Google spread sheets (Google, 2012). The graphs were saved as PNG images and compiled in Photoshop (Adobe, 2010). to stills, with the aim of visualising movement patterns specific to each emotion. These graphs, together with the chronographic time series and Circo*s* (Krzywinski *et al*., 2009) visual information on expressiveness in each of video clips, were used as a basis for the qualitative visual analysis of expressive movements described in the next section 5.2.4.10. *Triangulation, Quantitative Analysis of Visual Data.*

5.2.4.10 Triangulation, Quantitative Analysis of Visual Data

The triangulation process was divided into two parts. Part 1 was based on analysis of shape variations in each video in order to find the best key posture for each emotion. Part 2 focused on analysis of key postures in order to find the correlations amongst all the key postures, a similarity test. By using one data set to test its graphical model against other visual data sets it was possible to extract specific key postures characteristic of emotive movements, providing a foundation for the final Periodic Table of Movements visualisation.



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5.18 Triangulation diagram part 1, Hrynczenko, 2013.

5.2.4.11 Triangulation Part 1: Key Postures Estimation

Part 1 describes the evaluation process (figure 5.18) based on the triangulation method where the visual data was compared using;

Part 1 describes the evaluation process (figure 5.18) based on the triangulation method where the visual data was compared using;

- four diagrams for each emotion based on the visualisation of recognition points, presented in section 5.2.4.4 *Emotion Recognition Analysis According To Each Video Clip* (figures 5.10 to 5.14)
- time chronographic series (figure 5.19)
- plots based on spatial qualitative data (figures 5.20 to 5.21)
- shapes using *Movement Collections Quiz*.

Figure 5.19 Time chronograph for anger 001, Hrynczenko, 2013.

The time chronograph (figure 5.19) exemplifies only one of four emotions; anger and one of nineteen performers; 001. Using the triangulation method, in the first step, Circos's graphs representing movement recognition points for each emotion were analysed in comparsion to x, y plots (figure 5.20) and QoM plots (figure 5.21) in order to find the optimum recognition of expressive movements and the most movement data.

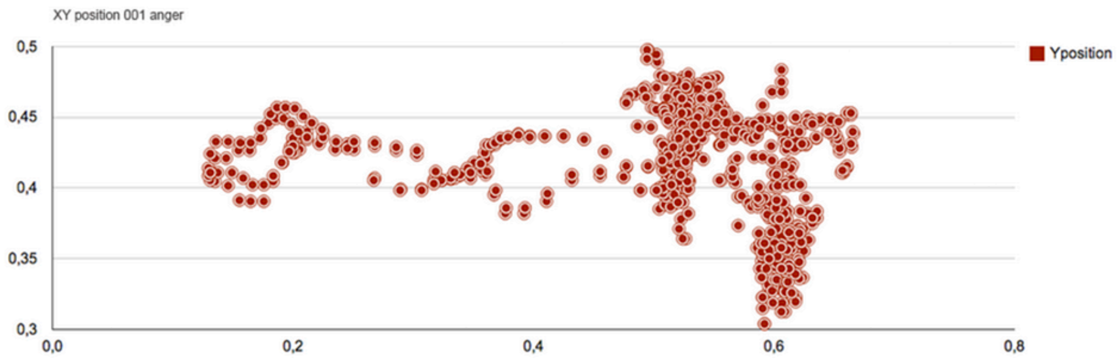


Figure 5.20 XY plot based on spatial movement data, Hrynczenko, 2013.

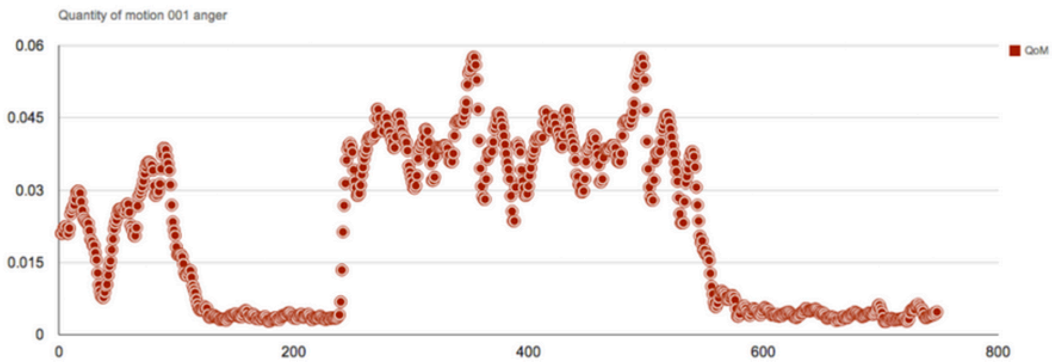


Figure 5.21 QoM plot based on spatial movement data, Hrynczenko, 2013.

In the next step, the chronographic time series was compared with the video collections in the Movement Collections Quiz. The intention of this process was to find which specific movement characteristics were most repeated in the videos that gathered the majority of recognition points. The visual analysis of the most representative of each of the emotion gestures was collected using the Silhougraphs® method ref? i.e. comparative and ocular analysis of the shapes of postures. Through triangulation, the silhouettes were used to estimate the movement tendencies for each emotion. A similar process was applied to analyse the expressions receiving a small amount or no recognition points. Finally, the characteristic movements from each video clip were compared across all movement representations of the same emotion where the most often repeated expressions were chosen. This deductive method allowed the extraction of the main differences between the expressions in the form of key postures. The exact visualisations methods are described in detail in section 4.4.9 *Visualisation of Periodic Table of Movements*.

5.2.4.12 Triangulation part 2: A Similarity Test

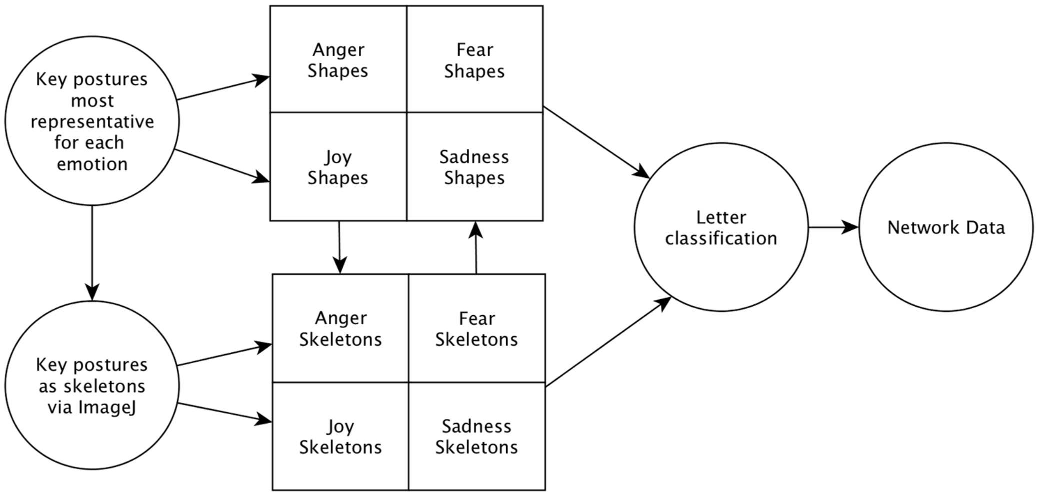


Figure 5.22 Triangulation diagram, part 2, Hrynczenko, 2013.

The second part of the triangulation process (figure 5.22) focused on the movements' characteristics, aiming to find similarities of expression across all key postures and emotions. The most representative key postures for each emotion were collected as thumbnails and converted to skeletons using *ImageJ* software's (Rasband, 1997) function for skeletonization of a shape in a binary image (figure 5.23).

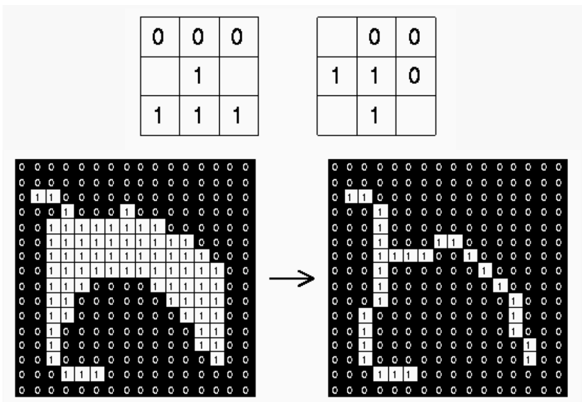


Figure 5.23 Skeletonization of a shape in a binary image, Wang, 2011.

Both shapes and skeletons were placed in tables according to each of four emotions, as presented in figure 5.24. All tables were based on the frequency of key postures from the video material. Using tables, similar postures were classified with the help of capitals that visually correspond to poses in the skeleton table (figure 5.25, 5.26). This way the capitals describe a group of similar postures that could be recognised across all four emotions. The labelling system builds the foundation for network analysis, and the visualisation of the Periodic Table of Movements.

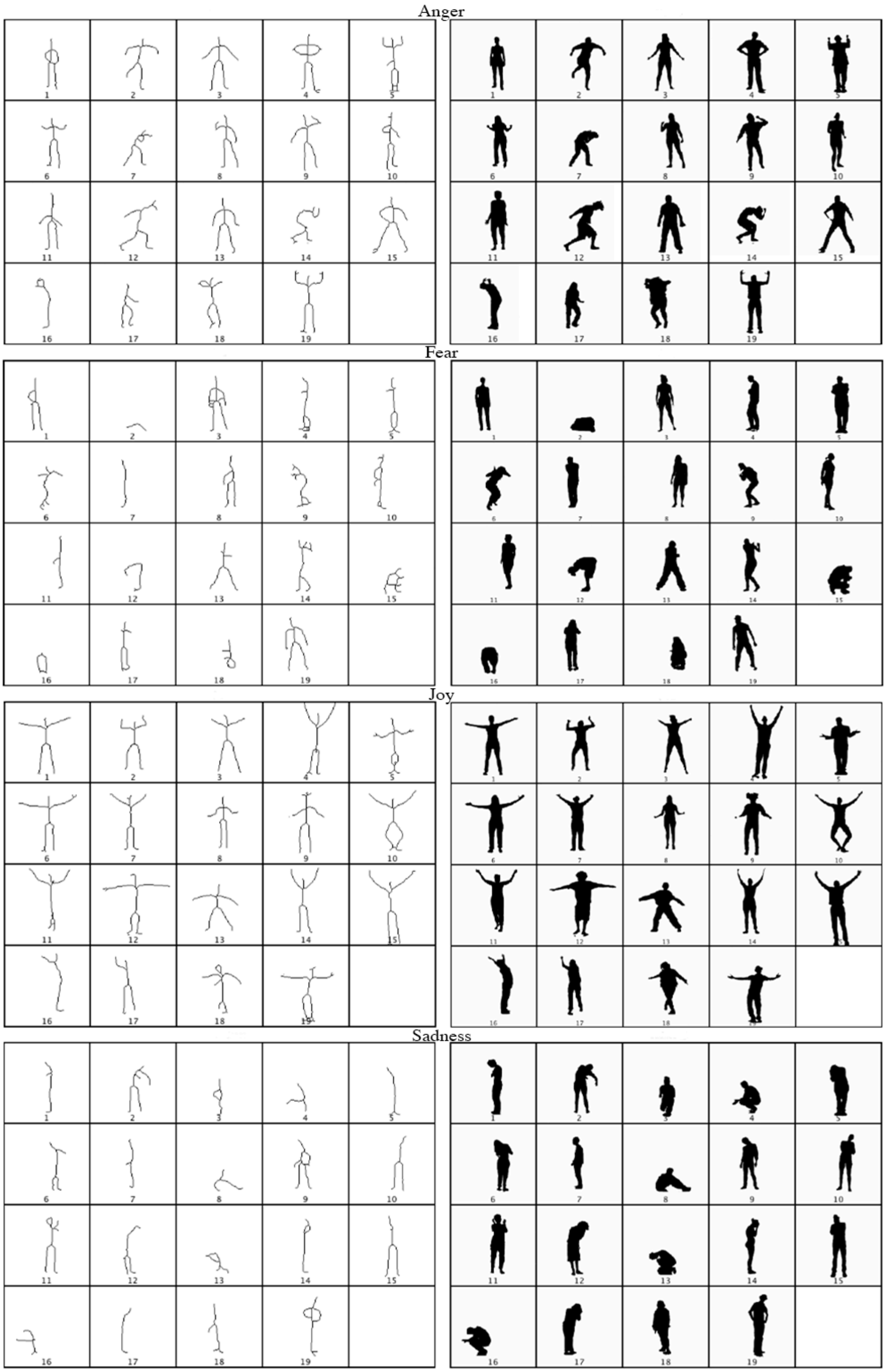


Figure 5.24 Posture diagram, Shapes and skeletons of all emotions, Hrynczenko, 2013.

The choice of capitals that visually correlate with the postures shape has a practical reason that has to do with my own visual memory. In fact, in the letter labelling process any letter combination could be used, since the purpose in this part of the triangulation process is to differentiate the groups conceptually (figure 5.25, 5.26).

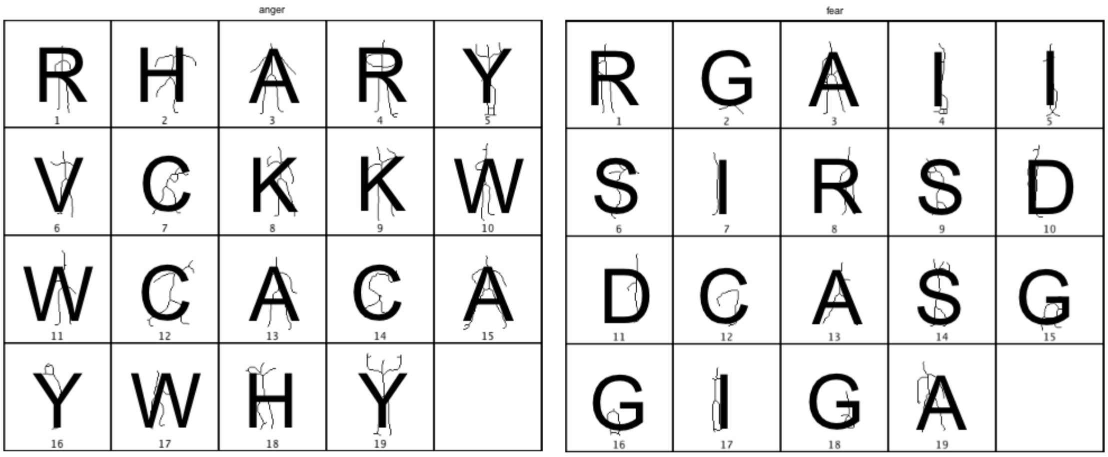


Figure 5.25 Skeleton table for anger and fear labelled with letters, Hrynczenko, 2013.

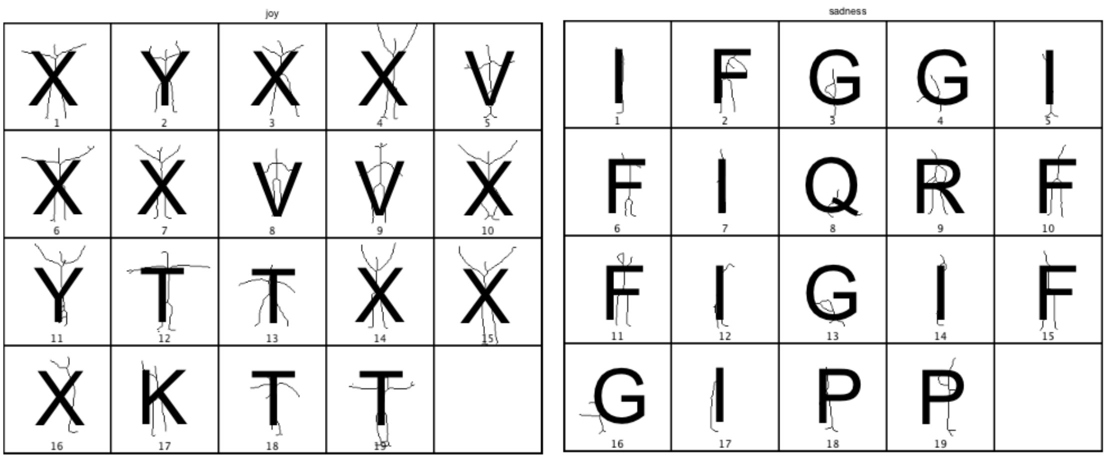


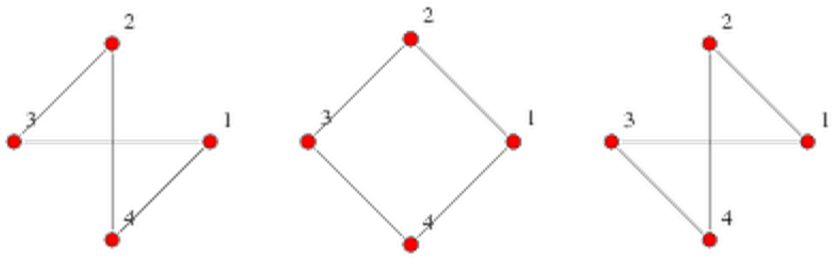
Figure 5.26 Skeleton table for joy and sadness labelled with letters, Hrynczenko, 2013.

The choice of capitals that visually correlate with the postures shape has a practical reason that has to do with my own visual memory. In fact, in the letter labelling process any letter combination could be used, since purpose in this part of triangulation is to differentiate the groups conceptually.

5.2.5 Network Analysis and Periodic Table of Movements

The Network is based on 17 groups of key postures that represent expression similarities among four emotions: Anger, Fear, Joy and Sadness visualised through key postures. Each group is named with the capital letter that visually corresponds to the emotive expression according to the charts in figures: 5.25 and 5.26. Both diagrams are extensions of previous versions shown in section 4.4.8 *Shape and Skeletons: Posture Comparison Process* that highlighted only two emotions. In the context of the network

analysis, it becomes important to present the conversion processes that illustrate the similarities of postures across all four emotions. This correlation data is presented in the table 15, later in this section.
Network analyses are based on connectivity matrix data created by connecting all the figures according to their respective letter labels. This was possible by using mapping features in the content mapping application, *Visual Understanding Environment* (VUE) developed by Tufts University (2003), which allowed the translation and export of connections among key postures via a table known as a connectivity matrix.



$$\begin{pmatrix} 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 \\ 1 & 1 & 0 & 0 \\ 1 & 1 & 0 & 0 \end{pmatrix} \quad \begin{pmatrix} 0 & 1 & 0 & 1 \\ 1 & 0 & 1 & 0 \\ 0 & 1 & 0 & 1 \\ 1 & 0 & 1 & 0 \end{pmatrix} \quad \begin{pmatrix} 0 & 1 & 1 & 0 \\ 1 & 0 & 0 & 1 \\ 1 & 0 & 0 & 1 \\ 0 & 1 & 1 & 0 \end{pmatrix}$$

Figure 5.27 Adjacency matrix example, Weisstein (n.d.)

In mathematics and graph theory, connectivity or an adjacency matrix is a way of representing connections among nodes in a graph. This is represented in a matrix table where the rows are equal to the columns and connections are represented by “1” for connection among nodes and “0” when a connection is missing (figure 5.27).

The table based on data from the VUE application as shown in figure 5.28 represents only a part of a larger table that contains all 76 control numbers from 001A to 019S for all four emotions. However, for clarity and Circos (Krzywinski *et al.,* 2009) requirements, all zeros were converted to an dash. The resulting patterns provided an indication of which correlations are likely to occur between individual expressions of the four emotions under investigation. During several iterations, based on the matrix data, different visualisations were produced as described in section 4.4.9 *Visualisation of Periodic Table of Movements*.

	001A	002A	003A	004A	005A	006A	007A	008A	009A	010A	011A	012A	013A	014A
001A	-	-	-	1	-	-	-	-	-	-	-	-	-	-
002A	-	-	-	-	-	-	-	-	-	-	-	-	-	-
003A	-	-	-	-	-	-	-	-	-	-	-	-	1	-
004A	1	-	-	-	-	-	-	-	-	-	-	-	-	-
005A	-	-	-	-	-	-	-	-	-	-	-	-	-	-
006A	-	-	-	-	-	-	-	-	-	-	-	-	-	-
007A	-	-	-	-	-	-	-	-	-	-	-	1	-	1
008A	-	-	-	-	-	-	-	-	1	-	-	-	-	-
009A	-	-	-	-	-	-	-	1	-	-	-	-	-	-
010A	-	-	-	-	-	-	-	-	-	-	1	-	-	-
011A	-	-	-	-	-	-	-	-	-	1	-	-	-	-
012A	-	-	-	-	-	-	1	-	-	-	-	-	-	1
013A	-	-	1	-	-	-	-	-	-	-	-	-	-	-
014A	-	-	-	-	-	-	1	-	-	-	-	1	-	-
015A	-	-	1	-	-	-	-	-	-	-	-	-	1	-
016A	-	-	-	-	1	-	-	-	-	-	-	-	-	-
017A	-	-	-	-	-	-	-	-	-	1	1	-	-	-
018A	-	1	-	-	-	-	-	-	-	-	-	-	-	-
019A	-	-	-	-	1	-	-	-	-	-	-	-	-	-
001F	1	-	-	1	-	-	-	-	-	-	-	-	-	-
002F	-	-	-	-	-	-	-	-	-	-	-	-	-	-
003F	-	-	1	-	-	-	-	-	-	-	-	-	1	-
004F	-	-	-	-	-	-	-	-	-	-	-	-	-	-
005F	-	-	-	-	-	-	-	-	-	-	-	-	-	-
006F	-	-	-	-	-	-	-	-	-	-	-	-	-	-
007F	-	-	-	-	-	-	-	-	-	-	-	-	-	-
008F	1	-	-	1	-	-	-	-	-	-	-	-	-	-
009F	-	-	-	-	-	-	-	-	-	-	-	-	-	-
010F	-	-	-	-	-	-	-	-	-	-	-	-	-	-
011F	-	-	-	-	-	-	-	-	-	-	-	-	-	-
012F	-	-	-	-	-	-	1	-	-	-	-	1	-	1
013F	-	-	1	-	-	-	-	-	-	-	-	-	1	-
014F	-	-	-	-	-	-		-	-	-				-

Figure 5.28 Part of adjacency matrix of connections among key postures, Hrynczenko, 2013.

The next step of the analysis was exploratory and based on visual interpretation of the connectivity matrix data visualised in the form of graphs. The visual observations were converted to a table and used as the basis for the analysis.
These are supported with parts of a larger network image in Appendix L and emphasising only the posture groups that are considered with regard to their size.

The network is based on 17 groups that represent expression similarities among the four emotions: Anger, Fear, Joy and Sadness. The table is colour-coded where red = anger, green = fear, yellow = joy, blue = sadness and relate to homogenous groups of expressions.

The results, based on a graph presented in Appendix L in 1:2 scale are magnified to show the details in figures 5.29 to 5.36. The correlations among the groups of the network and the basis of the analysis are presented in Table 15.

Table 15 Visual network data converted to numbers, Hrynczenko 2013.

Postures group name	Anger	Fear	Joy	Sadness	Postures represented in one group
I		4		6	10
X			9		9
G		4		4	8
R	2	2		1	5
Y	3		2		5
F		5			5
A	3	3			6
V	1		3		4
C	3	1			4
T			4		4
K	2		1		3
W	3				3
S		3			3
H	2				2
D		2			2
P				2	2
Q				1	1

The first part of the analysis looks at the homogeneity of expressions in the same group (i.e. the similarities of emotive postures that belong only to one emotion) represented in the table with colours that correspond to each of the four emotions.

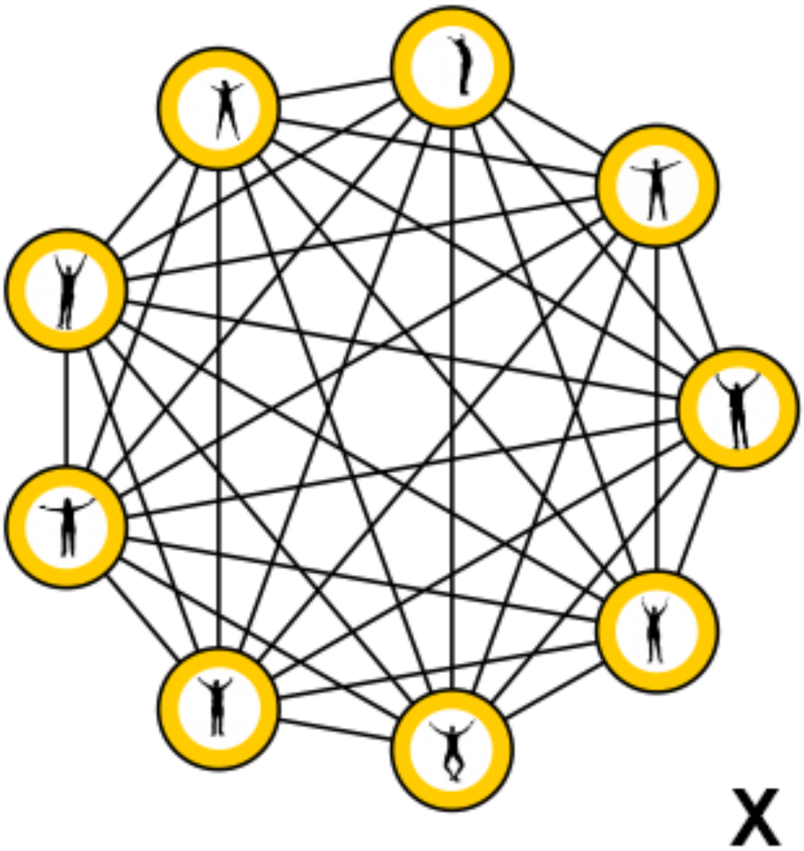
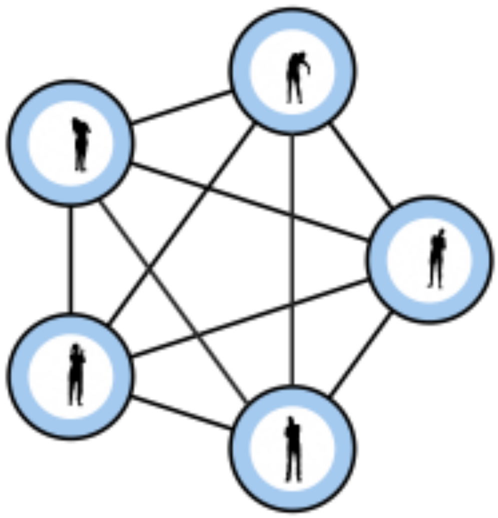


Figure 5.29 Network analysis, key postures for group X, Hrynczenko, 2013.

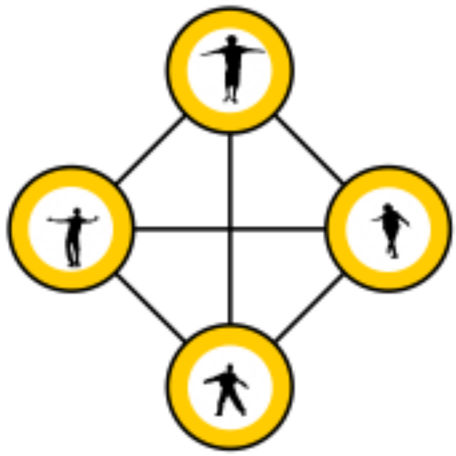
The aggregated data shows that the emotion Joy has the most distinctive expressions among the four emotions, a finding based on the posture labelled as "X" (figure 5.29) which had the most homogeneous network structure based on the number of nodes, nine in this example.

The next homogeneous group "F" refers to fear containing 5 similar expressions (figure 5.30) followed by group "T" that represents the joy with 4 postures (figure 5.31). Group "W" refers to anger with 3 similar postures. Both groups "S" and "D" refer to fear with 3 and 2 similar postures respectively.



F

Figure 5.30 Network analysis; key postures for group F, Hrynczenko, 2013.



T

Figure 5.31 Network analysis; key postures for group T, Hrynczenko, 2013.

The networks—W, S, H, D, P, and Q (see Appendix L) also show homogeneity that applies separately to specific emotions, however, the postures represented are not frequent enough to be considered as a guideline of posture recognition for Kinect (Microsoft, 2010),

The next part in this study focuses on similarities of expressions across the four emotions investigated. Network group "I" (figure 5.32) contains the largest number of postures representing similar expressions. The ten key postures show the highest frequency of the same posture in all 17 network groups.
However, this network group contains the same applicable posture with four expressions assigned to Fear and six to Sadness (i.e. 2:3 ratio).

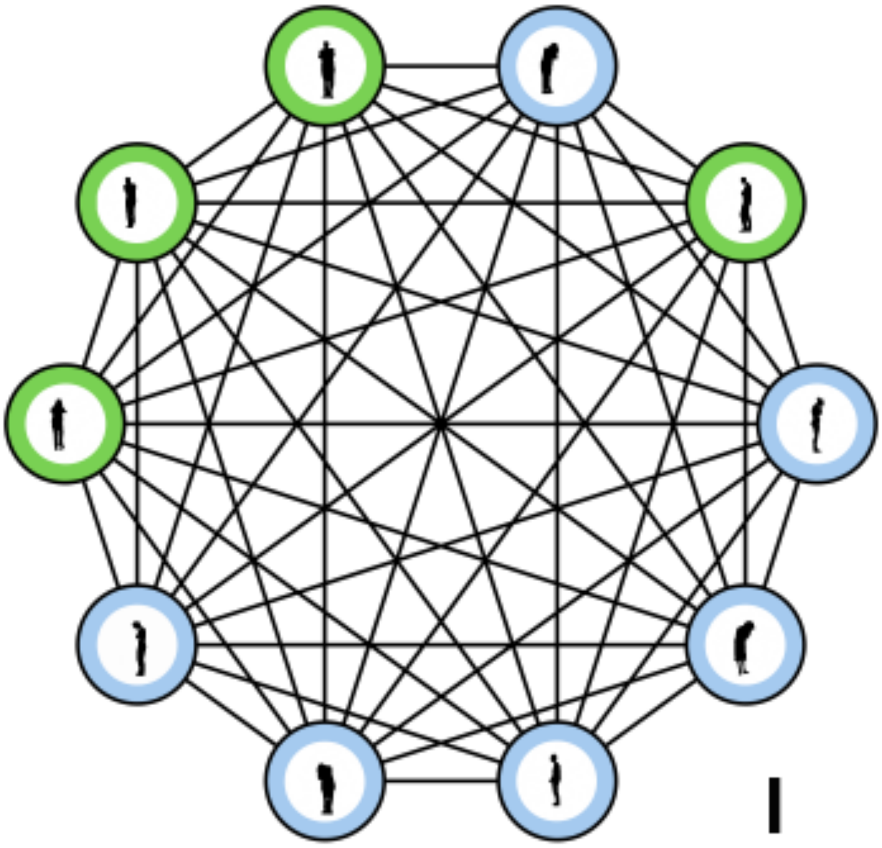


Figure 5.32 Network analysis; key postures for group I, Hrynczenko, 2013.

A similar connection is evident among postures in network "G" (figure 5.33) where the less frequent posture "G" is equally represented, five to five between Sadness and Fear (i.e. 1:1 ratio).

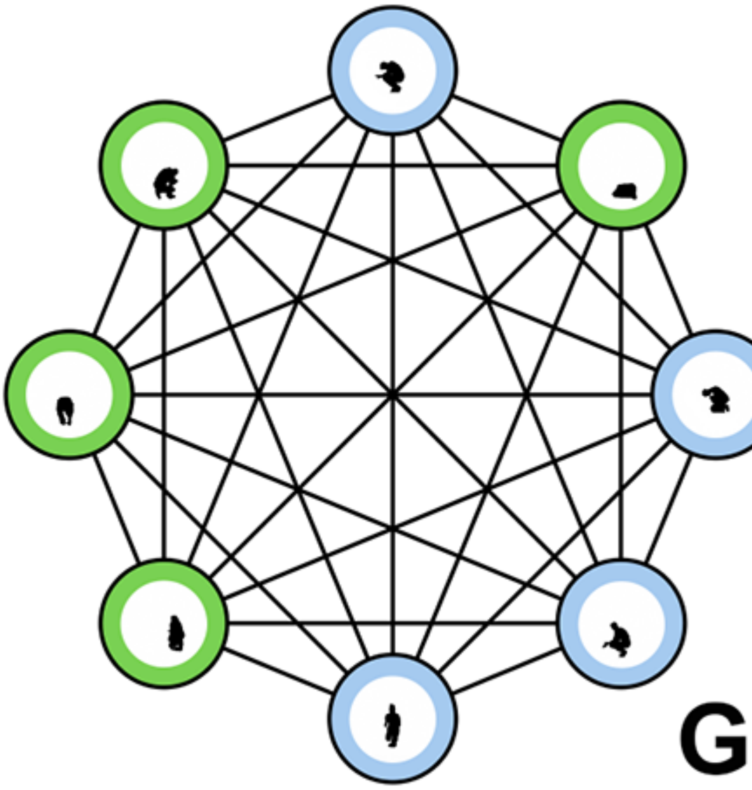


Figure 5.33 Network analysis; key postures for group G, Hrynczenko, 2013.

Equal division represents group A (figure 5.34), where less frequent postures are shared between Anger and Fear with 3 to 3 (i.e. 1:1 ratio). Despite the fact that these postures look quite similar, emotionally they have completely different implications.

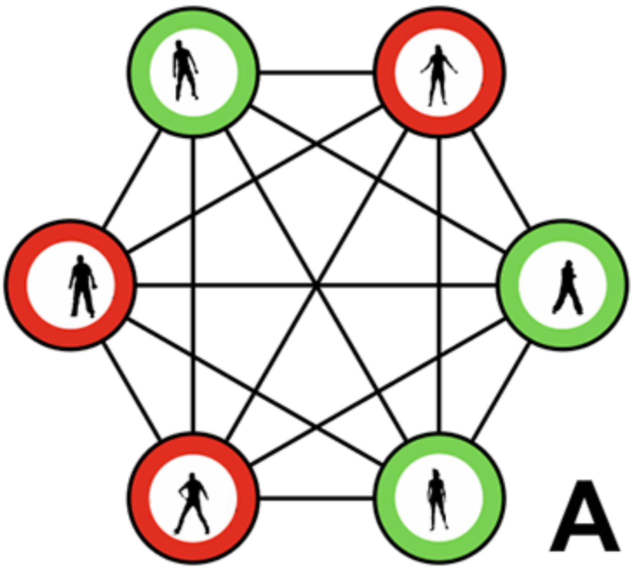


Figure 5.34 Network analysis; key postures for group A, Hrynczenko, 2013.

Similarly, group R is represented by key postures that refer to three different emotions; 1 for sadness, 2 for anger and 2 for fear, i.e. 1:2:2 ratio (figure 5.35). All five postures would be difficult to classify as a specific emotion without the context of previous and subsequent expressions.

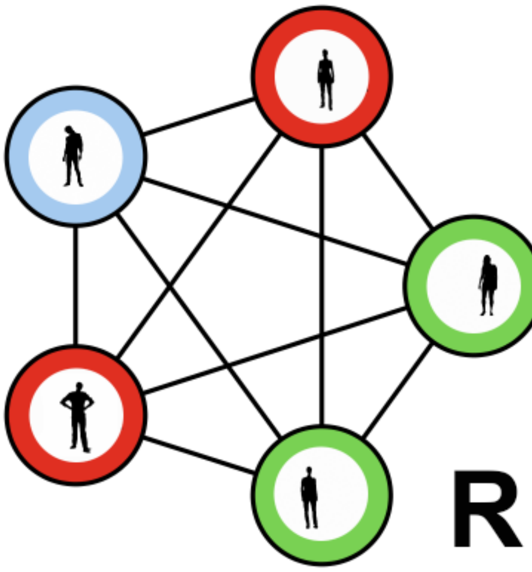


Figure 5.35 Network analysis; key postures for group R, Hrynczenko, 2013.

The same situation is evident in group Y where expressions of joy and anger are mixed by 2:3 ratio (figure 5.36). The correlations for the other groups in the network are visualised in Appendix L and calculated in table 15.

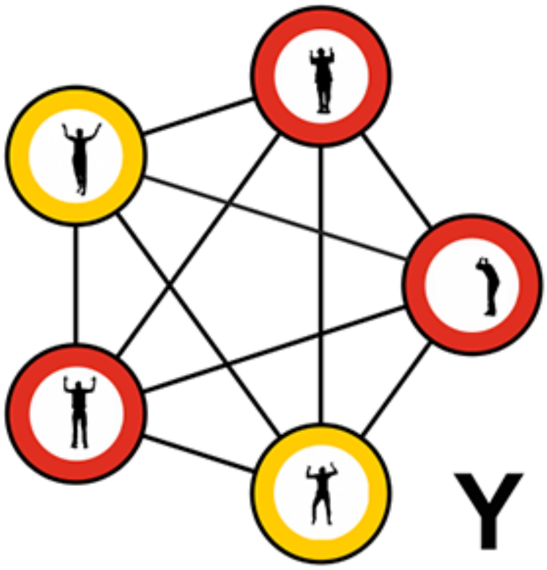


Figure 5.36 Network analysis; key postures for group Y, Hrynczenko, 2013.

5.2.5.1 Summary

The triangulation process provides a correlation table aiming to show the similarities between expressions of all four emotions indicating which postures characteristic for one emotion can be mistaken for another. The visualisation, however, is based on a complex process where visual, and qualitative data were compared and based on approximation and idealised varieties of an aesthetically resonable image.
Looking at the final results, the most homogeneous expressions are observed for the emotion Joy which is the most represented posture and categorised as posture group X described previously. Considering the previous findings (section 5.2.4) showing that emotions Anger and Joy receive the highest recognition factor of emotive expressions, it seems that expressions defined by group X are the easiest to recognise for movement sensing devices based on their clarity of expression. This may be a useful observation in the context of game design that is based on *Natural User Interfaces (NUI)*.

The visualisation processes provide the possibility of analysing quantitative data via visual patterns and to look for similarities and differences between emotions expressed by whole-body movements. The selected videos were analysed based on movement silhouettes in the chronographic time series, together with the kinematic data charts and plots to find the most representative poses as a symbolic representation of each emotion. The poses were highlighted in the chronophotographic timeline charts presented as additional information in the database. The graphs/stills of each video were saved as a part of the database. The triangulation process provided output in the form of silhouettes and skeleton charts that contribute to the network data. Using the visual method, Silhougraphs® (Kealiinohomoku, 1989) adopted from anthropological studies of dance postures, the characteristics for each emotion were arranged according to groups. The results of the analysis have indicated that the best-recognised emotions are expressed with clear and partly exaggerated volumetric movements. The intensity of the movements depends on the emotion. Both joy and anger by their nature are usually expressed with the whole body and with intensity and their parameters such as speed and volume are often increased. The extrovert nature of these movements are also connected to the communicative mean of these two emotions (i.e. expressive and unreserved), which makes them easy to recognise. In contrast, both fear and sadness are usually expressed with small and slow volumetric movements, often introvert and dependent on the state of mood, which in the digital environment makes them less recognisable. In summary, numerous human expressions consist of elementary basic movements that can be categorised. Although, several emotive expressions are unique, they differ based on the personal characteristics of the person that expresses them.

During the categorisation process each group of expressions were assigned a name based on capital letters according to their visual similarities with postures in the group. The capitals were connected with related filenames in the open source software VUE (Tufts University (2003) that has the capability to generate connectivity matrices, which in turn were imported into network software packages for further analysis and visualisation.Two final versions come together as the results of several iterations of network visualisations, both presenting the differences and correlations among emotive expressions for all four emotions. These two visualisations (Appendices L and M) are produced as A1 prints 59 x 74 cm (300 dpi) and represent one of the final outputs of this research; a prototype of the Periodic Table of Movements. Both are visual models of correlations of the embodied four emotions: Anger, Fear, Joy and Sadness, a result of various methods used for the analysis and categorisation of embodied emotion. The purpose of these artefacts is to stimulate interest for the application of emotive expressions in digital environments and contain symbolic value in the context of this research. Nevertheless, due to limited data samples, i.e. 76 video clips, the results received from these explorations should not be seen as definitive, but rather as an analytical model using visual aesthetics, and scientific methods to find an answer to several previously posed questions:

- How can Emotion be explained in the context of corporeal movement in order to be measurable?
- How are human emotive gestures correlated to each other?
- Which postures, emphasising emotive expressions, are best suited as key reference points for optical recognition devices?

Previous studies during the contextual research revealed that emotional expressions are reversible, i.e. physical expressions could release emotions, as well as that expressions of Anger and Joy are best recognised across cultures. In order to reach a closer understanding of how emotional expressions are related, much more data (i.e. video material) should be used and each frame should be analysed, not only the key frames but all frames in each movement sequence should be considered and evaluated. With this system, it will be possible to extract key postures of more generic characters based on the statistical data of appearance frequency.

6 Conclusion

This chapter verifies the key findings of the research and briefly describes the overall methods used in each part of the study. Due to the multi-layered scale and complexity of research undertaken in terms of the methods used and the parallel journeys embarked on, the summary of research is divided according to the following three areas:

- Contextual research: A Journey in Three Parts
- Documentation of embodied emotion and Database creation
- Qualitative and quantitative data evaluation and visualisation

For each of the three areas, a summary of findings is presented, followed by more in-depth detail of each key finding.
The three areas identified are broken down further into key findings within each subheading. A separate section is dedicated to answering the research question followed by a summary. To connect the present with the future, the impact of the research and plans for the future are discussed in the last two sections. The last section summarises the research followed by a discussion of the developmental potential for future research work.

6.1 Summary of Research Undertaken

The need for discussion on the representation of the human body in game worlds, its growing number of inhabitants and the neuroscientific findings connecting emotive expressions with empathy, have, in combination with the availability of more sophisticated motion sensing devices, highlighted a need to discuss and elaborate on the visual properties of emotion, as a part of education and research in games. This opportune scenario created a background from which the research question has crystallised:

How can emotions expressed via the whole-body movement be visually documented and archived as a reference framework to stimulate the use and studies of expressive gesture in digital environments?

As the question is posed it points out the need of a dialogue between physical bodies and digital space, which, in turn, requires new tools and platforms where both art and science can meet in a cross-disciplinary research environment. Taking into consideration these main issues behind the research question, this research focuses on the visual properties of embodied emotion. This study therefore reflects the findings of the contextual research, documentation of whole-body emotive expressions and database creation, as well as quantitative and qualitative data evaluation and visualization in order to address the research question.

During the iterative process of the research containing the contextual studies, workshops, movement documentation and evaluation, database design, data visualisation and analysis, a multi-method approach was applied and a set of subsequent methods used during the three-part study. The research is based on contextual and practice-based research where data evaluation supports the visualisation process. All three parts have contributed to a variety of outputs that are all connected to the investigation of human physical expressions of emotions.

A parallel process of this study and discourse is an investigation of visualisation methods as tools for knowledge conceptualisation and presentation where the subjective and objective view is discussed. The objective of this approach is to map the reference points between science and art in the production process of visual epistemic objects as content for the database. This is achieved by using scientific methods as artistic tools during the visualisation process and by the juxtaposition of a range of validation methods, from scientific quantitative processes, to qualitative arts-based contextual approaches. The first of these is represented in section 5.2 *Evaluation* and the second in Chapter 4 *Art as Vehicle, Research in Practice.*

6.1.1 Contextual Research: A Journey in There Parts

Through the contextual research the study documents the possibilities that exist in other fields such as: media art, dance performance and performance art in new media, that could be explored and employed to extend the pervasive and kinaesthetic games design. My choice of these preferences is based on my experience of practice in cross-disciplinary environments such as through the DAMA network and workshops. During the workshops, these different cultures: game design, computer science, media art, dance and performance art, mix together in cross-disciplinary projects, which have been shown to have a positive effect on game project design outcomes (Hrynczenko and Knutilla, 2014).

In line with these experiences, the contextual research is on the one hand, a contextual reference for practice-based inquiry; on the other, it is a collection of case studies aimed at highlighting the importance and potential of expressive gesture for games and the value of performance art to game art and design.

A review of research and practice in the fields of science and art revealed that in terms of emotions expressed as whole-body movement, an increasing interest has been noted across different fields of knowledge. Behavioural studies of emotion in Psychology often include corporeal expressions, a research interest also shared by Human-Computer Interaction studies, where research is ongoing in movement recognition technology. This is an interest shared equally by New Media fields, Music Studies and Performance Arts. The development of optical sensory devices is incorporated in games development focusing on body-centred research, but in a limited scale in terms of motion versus emotion studies. The emerging technical development with this new knowledge in new media art, neuroscience, games development, performance art and biometrics, opened the door to the ongoing paradigm shift confronting the human ability to be "*multisensory"* (learning through all senses*),* which requires cross-field research and practice. In this scenario, the emerging technology seems to be a common denominator and a shared field of interest.

6.1.1.1 Emotions, Science, Art and Virtual Worlds

There exist a controversy about scientific evidence for how emotions are executed in terms of the body and cognition. However, based on theories from different knowledge fields (Darwin, 1872; Damasio, 1994; Havas, *et al.*, 2010; Plutchik, 2001; Prinz, 2004; Altarriba, *et al.*, 2003; Merleau-Ponty, 1962) an assumption has been made that human emotional expression and visual perception are superior cognitive processes.

Human emotive expressions are patterns of bodily change, which we use as communication tools. Emotions developed over a long evolutionary process conditioned by a need for survival, in which the socio-cultural environment shaped bodily expressions. (Plutchik, 2001; Preston and De Wall, 2002; Bellman, 2002; Mauss, 1979/1935; Miyamoto and Ryff, 2011). In terms of emotion recognition, an essential finding based on the investigation of facial emotions recognition research, reveals cross-

cultural universality for six basic emotions; happiness, surprise, fear, sadness, anger and disgust. (Fridlund, Ekman and Oster, 1987). However, most of the research in psychology, anthropology and cognitive science refers to facial emotion recognition where extensive work is being carried out. On the contrary, when comparing current work on whole-body movement, it seems that whole-body movement recognition research is underrepresented.
In this regard, I refer to the theoretical basis that considers the body and corporeality such as in anthropology and the work of Mauss (1979/1935) or phenomenology and to philosophy and Merleau-Ponty (1962,1971). I conclude that both of them took the trouble to overcome the famous dichotomy between thought and matter inaugurated by Descartes (1644). In the context of this research both of them point to the necessary holistic view on embodied emotion. Mauss contextualises bodily expressions as socio-culturally conditioned, and Merleau-Ponty points out the importance of the communicative aspects of expressions in terms of "inter-corporeality". Correspondingly, Merleau-Ponty's work by Crossley (1995) highlights that bodily expressions always have a receiver. In terms of the PTM database, it is an essential aspect of the "lived other", formulated by Van Manen (1990) as relationality/community.

However, following Plutchik's (2001) research, I choose eight basic emotions as a basis for the documentation process targeting: anger, anticipation, disgust, fear, joy, sadness, surprise and trust. The need to find a conceptual descriptive model for data visualisations stressed a focus for the investigation on colour use in relation to emotions in science, art and design. These explorations pointed out a convergence in terms of the symbolic values of colours assigned to emotions (O'Brien, 2007) and the metaphoric use as analytic concept description (Plutchik, 2003). In the artworks, designs and scientific images investigated, the same colour combinations were found: red for anger, green for fear, yellow for joy and blue for sadness. These colour combinations make a potential case for the need of standards in the context of a visual description of emotions. Therefore, I adopted this system in my working process as a standardised version of colours that conceptually describe emotions and used these in a database tagging system and for data visualisations where emotions needed to be conceptually highlighted.

In terms of the research on virtual worlds, discussions about emotions versus cognition

is an ongoing process where the importance of emotions in the development of artificial intelligence (AI) agents is highlighted in the context of experimental laboratories as test beds for research on emotional reasoning (Bellman, 2002; Palosaari, 2011).
In general, this part of the contextual research suggest that more holistic cross-disciplinary research is needed on emotions in virtual environments as well as research on the visual perception of emotions as whole-body movements.

In general, since most of the past studies almost exclusively have focused on facial expressions, the contextual study suggest that more research is needed on emotions and particularly on emotive expressions in the context of virtual environments. In the course of this finding and as a result of this research, a method for emotive movement categorisation is proposed on the basis of the visual perception of emotions as whole-body movement. The database together with *PTM System and Database Infographics; A Proposal for further development of PTM database with movement sensing devices* (Appendix D), provide a point of departure for future interactive applications and comparative systems for movement recognition via interfaces such as Kinect Microsoft, (2011b).

6.1.1.2 Movements, Body, Art and Technology

This part of the contextual research demonstrated that in terms of kinaesthetic perception, the research has been primarily directed by cognitive science in parallel to art-technology developments in the performative and visual arts fields. In this context, several areas were investigated; presence in the body, emotive movements, visual representation, technology for body movement capture, body movement recognition and body movement interpretation in art. The investigation explored both technical and artistic approaches connected to the PTM project focusing on perceptual interfaces and movement recognition. Case studies of old techniques and new approaches in the dance and performance areas highlighted that the expressiveness of silhouettes amplified the visual perception of the human body in motion. One of the more substantial findings to emerge from this part of the research relates to emotive movement's reversibility (feedback loop). In particular, the research of Isbister (2011) and Cuddy (2012) provided the insight that the PTM development could be applied by using this feedback loop, as an expressive movement reverse process allowing access to emotions as a method for rehabilitation.

In terms of technological advances in the context of corporeal engagement, the research has revealed that the situation in game development has changed rapidly with body-centred knowledge entering the scene. Development of motion sensing devices is already taking place in computer labs and research facilities of leading games development companies. Microsoft's Kinect Microsoft, (2010) for the game console Xbox 360 provides a platform for experimentation and research beyond its intended commercial use and the field of game design, thanks to its open source software development kit (SDK). Movement-based technology is also developing rapidly as a result of the growing field of the dance-technology art scene. This is due to the independent community of artist-technologists, hackers and computer geeks who often provide the open source tools. Referring to the findings described above, movement-sensing technology is opening doors for a paradigm shift in the way we look at the human body and expressive gesture in the context of digital environments. It is therefore extremely important that the tacit knowledge contained in centuries of performance art culture is incorporated into technical developments.

6.1.1.3 Database, Movement and Data Visualisation

The focus on arts was intentional since investigations on the human body and movement in the context of the database, and the technology behind it, are discussed in these fields from several perspectives. Cross-disciplinary knowledge exchange is a part of today's art culture where discussions often take place in philosophical, socio-cultural and political contexts. The investigation of a database concept as an artistic and research tool provided insights into the vast range of asociated artworks and art research projects. The intention is that the database is not used only as an information depository, but also aimed at providing a platform for the ongoing development of new artworks and research, thanks to its open, public digital archives. This open source data, whether visual or quantitative, provides several outputs extending the value of the original concept to other fields of knowledge. The possibility of making and remaking, utilising the same data, renders the database concept an effective tool for art and research. This is not only because the system of the database provides a structure for the creation of different narratives from the same content, but also since it creates the possibility of interpreting the same data sample from multiple perspectives. This quality extends the question of the subjective and objective beyond scientific validity by an approach that explores existence as multiple and multimodal layers of reality.

My search for the factual representations of emotion that can be measured and quantified, brought me to the philosophical detour expressed by the question:

‘How much influence does the identity have on the identifier?’

The issue of numbers as the objective evidence of truth has been a controversial and much-disputed subject within both the fields of science and art. From visual data collection to the transformation of embodied expressions into numbers and later to charts and diagrams, the issue of validity continued to be tested throughout this research in the context of the PTM database. The issue of the reliability of the collected data and the methods used for visualisation as well as the process of the database design was an exploration of models of inquiry on which our perception of the modern world is built. As a reflection of this exploratory journey, my conclusion is that during the data transitions from one media to another simplifications and generalisations often occur. Therefore, to understand emotions whilst maintaining the complex correlations between their socio-cultural characteristics, multimodal representations of each emotion are required and from different perspectives when considering individual data samples. This strategy provides a sufficient amount of information in order to make associations between the different representations, measurable and quantifiable. Nevertheless, to understand the phenomenon of emotive expressions, we should not just see the behaviour but also interact with it, measuring it and transforming it into various representations and within a broader context.

6.1.2 Documentation of Embodied Emotion and The Database

The PTM data set consists of 152 videos representing eight basic emotions; anger, anticipation, disgust, fear, joy, sadness, surprise and trust. However, 76 videos of four emotions: anger, fear, joy and sadness were converted to silhouettes in motion through the postproduction process and archived in the database.

The documentation of exaggerated movements expressing the eight emotions is based on individual participant interpretation of the movement as if performed on stage. This exaggerated behaviour was desirable, but was not requested originally, rather these were introduced through the playfulness of the *Shadow Da*nce exercise (Hrynczenko, 2009a) introduced as a way for participants to feel more consciously attuned to their bodies.

The video recordings also highlighted how the expression of emotions are influenced by contemporary film and media as a result of socio-culturally conditioned bodily expressions of emotion. Mauss (1979/1935) described this phenomenon of copying as socio-cultural attachment whilst Foucault (1995) emphasised the “docile body” as physical behaviour socially and politically controlled, in this case, by the authority of media. In the context of the database and from the perspective of this research, the current collection of expressions is just a sample that reflects how exaggerated emotions are influenced and could be expressed. The element of exaggeration is applied in order to gain a clear picture of emotive expressions. This approach was essential in order to differentiate properties of the four emotions that would be applicable for game character walk cycles and at the same time provide silhouettes recognisable by Kinect’s depth sensing capabilities (Microsoft, 2011b).

The collection of 76 video clips constitutes the primary data set from which several secondary artefacts were produced as content for the PTM database such as sets of:

1) 76 digital images that represent movement patterns created as chronophotographic timeline charts.
2) 2 collections presenting graphical visualisations of movement such as 76 graphs of xy positions and 76 graphs of the quantity of motion in relation to time.
3) 4 video collections, Movement Recognition Quiz in which each of the four collections consists of 19 rapidly reviewable videos.

The database also contains *Emotion Recognition Graphs*, which is a collection of five *Circos* (Krzywinski *et al.,* 2009) charts, four diagrams for each of the emotions and one diagram that visualises the correlations among all emotions in terms of the expressions communicative qualities. The charts are a visual output of the online survey where the expressiveness of embodied emotion was measured according to each of four emotions. The aim of these graphs is to provide the PTM database users with information about the expressiveness and readability of the gestures for each actor and each video clip. The creation of the PTM database has an ontological character where the main focus is on the content for the PTM database. The structure of the database is built in two phases; design and implementation, in which the latter was developed in cooperation with a programmer. The content creation process is based on the analysis and mapping of body language through the evaluation of the communicative qualities of expressions and data visualisations. For this purpose, in exploring the convergence between art and science, I used scientific methods as artistic tools for the image creation.

The online database is a main output of this inquiry, which contains a collection of digital assets that emphasises the properties of emotive expressions as visual concepts of emotion such as: shape, space, volume, time and the communicative qualities of expressions. The assets were produced as explanatory epistemic objects and in the context of character development for games and expression readability for movement sensing devices.

The intention of this archive is to provide a pedagogical toolset for movement analyses, aimed primarily for use by students and educators in game design and graphics. However, the universality of emotional expressions as tools for communication make the database useful for students, educators, artists and researchers from various knowledge fields. The aim of the PTM framework is to provide an environment and toolset for engagement and reflection on human kinaesthetic and visual experiences. The collection of time-based and visual data contained in the framework provides sample data for experimentation, but additionally, it aims to advance the application of emotional expression recognition in games, by showing how the framework could be applied as a multimodal analytic tool.

6.1.3 Qualitative and Quantitative Data Evaluation and Visualisation

During the process of analyses, the video data has been investigated using both qualitative and quantitative methods, in which the different properties of emotion have been explored and visualised. The quantitative analysis evaluates gesture expressiveness and readability for each actor and each video clip, i.e. the communicative qualities of the selected video material. Whereas, the qualitative analysis was focused on the similarities and differences among postures characteristic of each emotional expression contained in the video material. The qualitative process builds on a triangulation methodology providing the basis for the exploration of methods for the network data visualisations, as well as providing the data for the visualisation of the Periodic Table of Movements.

Data visualisations of expressive movement as the quantifiable content of the database and the final output of this doctoral study are based on a comparative method of the results from the online survey and triangulation via visual interpretation. The findings are only noteworthy in relation to the communicative value of expressions in each of the video clips in the database. However, they have some implications for future adaptation of the database for use with optical, movement recognition interfaces such as Kinect (Microsoft, 2010), where the typology and clear differences between expressions contribute to movement recognition and the classifications of movement input data.

The findings presented in regards to the data contained in the video clips, refer to the communicative qualities of each of the video clips by measuring the readability of the expressed emotion. The results collected from the online survey are divided into four sections, for each of the four emotions according to the database divisions. The results of the survey together with the information of each video clip provided a basis for five graphs, four for each emotion and a combined one of all the emotions. These provided information about the readability of the expressions and established the groundwork for a study utilising circular graphs as a method for visualisation techniques.
The study employed central tendency measurements, using the mean of the total recognition score. The results show that the video data associated with the emotion Joy attained the highest gesture recognition score with 76%, followed by Anger with 73%, Sadness with 58% and Fear with 55%.
The visual output of these explorations constitutes a part of the PTM database in the form of Emotion Recognition Graphs, four for each of the emotions and one amalgamated graph connecting the scores with each of the actors. Expressiveness scores are provided for database users as an indication of the communicative qualities for each of the 76 video clips. This is one of the useful features applicable to animation studies by providing a scale of expressiveness for each of the actors and the emotion articulated.

Visualisations of quantitative data received from the triangulation process provided a basis for the Periodic Table of Movements, a correlation table of similarities and differences within and between the four emotions examined; anger, fear, joy and sadness.

Mendeleev's (1869) pioneering work on the basic building blocks of the periodic table of chemical elements clasified according to their atomic number became the conceptual inspiration for the Periodic Table of Movements. The differences and similarities among postures and gestures were categorised according to their connections based on their network data and with the help of several visualisation models. Piutti's (1925) circular design provided the best model for the visualisation of expressive posture

correlations. The first ‘rhizomic’ structure among the correlation visualisations did not provide enough clarity. As the experimental part of the research continued, a more suitable design crystallised into a visual model of networks, a prototype of the Periodic Table of Movements.
The model however did not yet provide a complete picture of possible relations among emotive expressions since only four emotions were represented. The Periodic Table of Movements provides an evaluation of two of the most important questions of this research, one being ontological in its nature; what is expressed emotion? while the other methodological; how could it be quantified and visualised?

In order to establish associations between the individual expressions with emphasis on each of the four emotions, a visual network was adopted as the final model of expression.
In this structure, emotions expressed as non-verbal corporeal expressions are not classified or sharply defined, separate, controllable and assessable in terms of defined qualities as they always exist in correlation with other expressions, interconnected in the world of other humans, incidents, actions and reactions.

Although emphasising the correlations among emotive expressions, visualisations carried out through several iterations created the final network diagrams that show the characteristic postures for each emotion and their correlations to the data samples (Appendix L). Based on the visualisations of these expressions for each of the four emotions and their relationships, two types of networks were created and reproduced in the form of A0 prints.

6.2 Answering the Research Questions

The practice-based part of the research is an investigation of methods, approaches and is of an exploratory nature, which concluded with several artefacts contained in an online database. The research was undertaken in order to design a database of human whole-body emotive gestures with the intention of providing sample material as a research tool aimed at stimulating the study of embodied emotions in digital environments, and particularly games while addressing the research question:

How can emotions, expressed via whole-body movement be visually documented and archived as a reference framework to stimulate the use and studies of expressive gesture in digital environments?

As a consequence the following sub-questions become relevant for this research: One, ontological in its nature; what is expressed emotion? and the second, methodological; how can bodily expressed emotions be visualised and quantified?

Several other related sub-questions unfolded during the research process referring to both philosophical and practical/technical issues and became, in the broader context, equally meaningful for the study:

What is Emotion in relation to bodily expressions? Are emotions expressed via movement and gesture on screen equally recognisable across cultures?
How could whole-body emotional expressions be visualised and transferred with the help of "The Digital”? How can Emotion be explained in the context of corporeal movement in order to be measurable? How does physical data influence virtual data and how can we visualise such complex patterns?

As an effect during the building of the database and in connection with the video material, secondary questions evolved such as: Which emotive expressions have the best recognition factor? How are expressive gestures connected to each other? Which postures that best emphasise emotive expressions are more suited as key reference points for optical recognition devices?

During the contextual investigation, elementary issues attached to expressive movement and gesture were also explored through the question:

What is Emotion in relation to bodily expressions?

In order to find an answer, the first part of this research focused on which cognitive and bodily processes are involved in different emotional states and their relationships to human perceptions and actions.

Summarising recent research in the fields of philosophy, psychology, and neuroscience, new findings support the conclusion that bodily changes and the experience of the body are inextricable aspects of emotions, and of most other aspects of the mind. (Darwin, 1872; Damasio, 1994; Havas *et al*., 2010; Plutchik, 2001; Prinz, 2004; Altarriba *et al*., 2003; Merleau-Ponty, 1962). These theories conclude that the corporeal experience of the body is both an aspect of emotion and of the mind where human emotional expression and visual perception are superior cognitive processes. Emotive whole-body movements and gestures are highly connected to social communication skills developed during a long-term evolutionary process and are highly important as a communication tool in social environments. Examination of numerous studies reveal that there is a convincing connection between emotional expressiveness, empathy and pro-social behaviour, thus strengthening the argument that bodily expression should play a significant role in the development of digital environments. In this study, these behaviours or qualities are elaborated in a contextual review highlighting the correlations. One of the most meaningful findings of this research that should be taken into consideration, and particularly for the future development of games, is that human expressed emotions are reversible, i.e. facial expressions, body movement postures and gestures can provoke emotions.

In summary, these conclusions provide the framework for understanding how emotions are initiated and regulated in mind and body, noteworthy points that I hope will resonate in the development of new technology and virtual environments. Accordingly, the importance of research environments that focus on expressive movement and gesture, as well as developing new methods and cross-disciplinary knowledge exchange has been emphasised in this study, both during the contextual review as well as throughout the critical discourse and practice-based research.

During the investigation, perceptions of emotions became one of the important issues

for the database design revealed by the question:
Are emotions expressed via movement and gesture on screen equally recognisable across cultures?

To answer this question I used a survey together with contextual research. However, the survey, due to the respondents small sample size, could not be used as a basis to answer this question. Therefore, the contextual research on the facial recognition of emotions becomes a foundation on which to develop the conclusions; a choice based on the lack of existing adequate research of expressive whole-body movement recognition. Research on the facial recognition of emotions concludes that a large degree of universality of emotional expressions exists among six basic emotions; happiness, surprise, fear, sadness, anger and disgust, enhancing Plutchik's theory of emotions (1980) and providing a solid basis for the database construction. Both the survey answers and the contextual research indicate that emotions such as joy and anger have the best recognition results across cultures. Similarly, based on the contextual research, a structured colour scheme that could conceptually describe emotions already exists. These findings strengthen the correlations between emotions and colours in Plutchik's colour wheel that become a model for the tagging system in the database.

In order to find an adequate method for the visualisation of movement data, two questions address the issue contained in the main research question by reflecting on the problem of depicting the simplification of emotional intensity expressed via movement and gestures occurring during the transition to the digital environment. Thereby, the issues are interlinked and require answering by investigation from different perspectives through the following questions:

How can whole-body emotional expressions be visualised and transferred with the help of "The Digital?" How can emotion be explained in the context of corporeal movement in order to be measurable?

The answers to these questions were investigated throughout the following sections 3.3 *Movements, Body, Art and Technology,* 3.4 *Database, Movement and Data Visualisation,* 4.3 *Emotions/Movement Documentation Process,* and 4.4 *Movement Visualisations Process and Data Aesthetics.* In order to present only whole-body expressions, the PTM database contains video material that displays silhouettes in motion excluding facial expressions. This approach was employed throughout all stages of the research maintaining focus only on the whole-body and gesture expressiveness.

A quantitative triangulation method was applied in the form of an online questionnaire, which was beneficial when measuring the expressiveness of human bodily movement and gesture. Twenty-five respondents ranked whole-body emotive expressions contained in 76 video clips according to the levels of expressiveness of the emotions and gestures being assessed. This procedure resulted in an emotion recognition factor measuring communicative qualities for each of the 76 videos. Four emotions, (anger, fear, joy and sadness), documented by recording the bodily expressions of 19 voluntary participants, were used as a basis for this inquiry. The data collected was employed for diagrams that served as indicators of the communicative qualities of each video clip and for each of actor, ranking gesture expressiveness in relation to emotion recognition. Additionally, the data was used during the triangulation process to obtain the most representative postures for each of the emotions as compared with the three parameters of the movement data.

During this stage, the movement measurements were processed through video data analysis, which provided quantified data of movement based on parameters such as; time, xy position, absolute velocity and quantity of motion (QoM). The correlations among emotive expressions were quantified using both visual analysis and network matrices, which also has a bearing on the useful identification of generic postures with optical, movement sensing devices such as Kinect (Microsoft, 2010). This section of the research was developed as part of the triangulation method and via tools adapted for the analysis of microscope imaging and network visualisations, most commonly used in biology and medicine. Both approaches are described in the sections 5.2.4.7 *Spatial and Visual Data Analysis* in which part of the triangulation is described and 5.1.9 *X-Ray of Emotional Kinesphere* covering the process of image digitisation.

To visualise movement patterns the results of the movement analysis were converted to charts and diagrams that visualise the expressive movement from each of the 76 videos for xy coordinates and Quantity of motion (QoM) in relation to time and space. The results are presented in the database both as collections classified according to each of the emotions as comparative scatter plots aiming to provide an analytical overview model, and as additional information for each video. Similarly, statistical data from the survey evaluations are provided as an interactive collection of charts where users can compare emotion recognition points with chronophotographic timeline charts. This is a feature that contributes to the multifaceted nature of the data sources, aiming to emphasise the complexity of bodily expressions.

Accordingly, the complex issue of the movement characteristics of each of the performers is presented in the format of chronophotographic timeline charts and interactive video collections. This also includes a movement recognition game allowing users to progressively explore movement collections via movement recognition. To explore the collections users must specifically use their own visual movement perception to navigate through the collections of four emotions: anger, joy, fear and sadness. In support of my intention to provide the PTM database with various representations of movement data, the movement recognition game allows users to practice the identification of whole-body movement expressiveness. The purpose of this feature is to expose the movement perception of the user to the diversity of human emotional expressions.

The issue of the visual characteristics of emotions and their internal correlations is explored through visual and digital means via several steps of triangulation where characteristic postures of silhouettes were obtained from the video material and converted to network charts via a correlation matrix. Similarly, movement characteristics were investigated from the perspective of volume and time with the help of software tools used for microscopic imaging. In this process all the video clip frames were compressed into one frame using an opacity layer feature that simulated volume and space visualising movement changes over time.

In order to visualise these complex patterns, and as a point of departure for the future development of the PTM database, the following question arises: How can physical data influence virtual data?

As an answer to this question I propose the future development of the database in order to build a comparative database model that is synchronised with a movement recognition device such as Kinect (Microsoft, 2010); a proposal described in the form of an infographic presented in Appendix D; *PTM System and Database Infographics; a Proposal for further development of the PTM database with movement sensing devices*.

The main purpose of this visual proposal is to prepare a platform for future research, with the aim of using the PTM database to develop software for the comparison of emotive movement patterns. It is an extension of the doctoral research proposing to use the silhouettes as cross-reference material together with the data captured from a Kinect (Microsoft, 2010) device.

In this scenario, physical data could influence virtual data; where expressive whole-body movement data captured from the Kinect could be matched with the visual patterns of a particular emotion stored in the PTM database system. Furthermore, the database flowchart allows for potential features of the output information to be added in the future with scenarios for possible application areas where movement input data could be converted to produce visual and audio outputs. The strategy of this project is to integrate the open, relational systems of the database into future tools that will augment real-time performance. This concept incorporates the real time playback of time-based media, and enables an interactive synergy and integration between physical movement and the digital database in order to explore emotional expressions.
During these investigations, the possibility of using the database as a tool for research allowed exploration of the relationship between expressive movement, the database and its future use with movement recognition devices. The video data collected, become a basis for a series of secondary and tertiary movement visualisations, and also raised several questions as follows:

Which emotive expressions have the best recognition factor? In what way are expressive gestures connected to each other? Which of the postures that best emphasise emotive expressions are best suited as key reference points for optical recognition devices?

The answers to these questions are connected since the answer to the first question subsequently builds the basis for the next one. Based on outcomes described in section 5.2.4 *Emotions as Silhouettes in Motion, The Online Survey* that investigate a visual coherence between the silhouettes in motion in the video clips and the emotions of joy and anger, these show a high percentage of recognition. Findings based on recognition scores obtained from the online survey and measured using the central tendency mean value showed the score for Joy of M = 76% and for Anger M = 73%. These findings provide the basis for the following investigation where the best-recognised expressions converted to charts are explored in terms of similarities among expressions and with error scores, i.e. when expressions were misinterpreted and are used for comparison of the final results in triangulation process. The results of this investigation show that expressions of emotions fear and sadness often share similar expressions, while expressions of anger have shown the most diversity. The emotion joy seems to have the best homogeneity of expressions and is therefore best suited as a key reference point for optical recognition devices.

In summary, to study the phenomenon of emotion we should not just consider the associated behaviour but also interact with emotion physically by replicating it, and cognitively, by transforming and measuring it on the basis of its representations across all forms of media. In order to grasp the embodied representation of emotion, we need non-uniform representations for various categories of data.

6.2.1 Answering the Main Research Question

The central question posed at the beginning of this study reflects the findings revealed during the contextual research, as well as a need for an ontological approach to the visual properties of emotion essential for game character development. Equally, necessary is the reference object for use with optical, movement sensing devices as a basis for kinaesthetic game design. Accordingly, looking from this perspective, the importance of a framework for whole-body emotive-expressions as a platform for the elaboration of education and research emphasised the following research question:

How can emotions, expressed via whole-body movement be visually documented and archived as a reference framework to stimulate the use and studies of expressive gesture in digital environments?

The main intention of the practice-based research was to provide a platform in the form of a database aimed at future studies and research on embodied emotion in digital environments. Following this line of this thought, the study is focused on future visual representations of emotion such as: shape, space, volume, time, intensity and the communicative qualities of expressions. Therefore, as an answer to the question, the more substantial parts of the documentation process and how the content creation is deployed, underpins the construction of the PTM database.

The focus of the database is on emotion expressed as whole-body movement and gesture. Therefore, in order to emphasise emotional intensity expressed via physical movement, the database design excluded facial expressions by using silhouettes in motion as the only expression of emotion. The PTM database design is a pilot study, whereby, only four emotions were explored establishing the four main sections of the database according to the emotions: Anger, Fear, Joy and Sadness. The choice of these emotions is founded on contextual research in respect of their universality, mainly, since research has shown that these four emotions are recognised cross-culturally. The same set of emotions with the corresponding colour scheme is defined by Plutchik's *Psychoevolutionary Theory of Basic Emotions* (1980) and reflected in his *Colour Wheel of Emotions* (1980).

The division of the database into four sections that represent these four emotions constitutes the structure under which digital assets were stored, emphasising the properties of emotive expressions as the visual concepts of: shape, space, volume, time, as well as the communicative qualities of expression. The visual properties of emotion were analysed and produced in the context of character development for games and expression readability for optical, movement sensing devices thereby requiring exaggerated emotive expressions. The aim of this approach resides in the future use of the database as a framework for the studies of expressive gesture in digital environments., In the next step of the development, motion sensing devices will be implemented in which, both animation techniques and motion sensing devices will require more accentuated expressions.

With this purpose in mind, the emotional expressions performed were recorded as whole-body movements, converted to silhouettes and evaluated. This was undertaken mainly in order to provide an indicator for the database about the communicative qualities of each video and actor. Qualitative data from the evaluations were visualised providing the PTM database with five diagrams of gesture expressiveness for each of the emotions and one combined diagram that were added to the database as communicative quality charts. Each of the diagrams refers to each emotion, video clip and actor. Other visual properties of emotion collected in the PTM database are:
Shape; 76 videos presenting 30 second clips of silhouettes in motion
Space; 76 charts as visual patterns of xy coordinates
Volume; 76 charts of the quantity of motion

Time; 76 chronographic charts based on movement patterns over time created as superimposed video frames compressed into a panoramic image of walk-cycles (Both *Space* and *Volume* data sets were rendered from the kinematic analysis of movement videos)

In the scenarios presented in this study, movement analyses are based on two-dimensional space, but for a better understanding of movement, analysis of movement in three-dimensional space is recommended for the future expansion of the PTM database.

Throughout this research, a holistic approach is applied that has its origins in phenomenology, reflecting a phenomenological approach to human perception in a spectrum of four “existentials”: *spatiality*, *corporeality*, *temporality* and *relationality* (Van Manen, 1990). My aim with this approach is to transform this view into human interaction with digital content, where the whole human entity is considered as a component part of digital content development. In practice, it has been manifest during all stages of the database development and workshops and concludes with the visual assets of movement-based expressive content.

The holistic embodied approach to emotion, was crucial for the database design and development where *spatiality, corporeality, temporality*, and *relationality* were used and iterated through the design and working process. This approach is reflected in the database construction, the digital assets production and in the final output of this research. The division of created assets during the research reflects the integration of phenomenology’s holistic view. In respect of the research question, I propose a reference framework with a holistic approach, in which corporeality is represented by video data of silhouettes in motion (i.e. the body shape of emotion). Temporality is reflected in chronophotographic charts, quantitative data and graphs based on quantity of motion in time (i.e. the timeline of expressive gesture). Spatiality is represented by kinematic data of the movements xy coordinates and the visual data of the kinesphere (i.e. the locomotion and kinesphere of emotional expressions). The relationality/ communality is reflected in infographic charts of the communicative qualities of expressions and the similarities and differences among expressions.

6.3 Impact

The database provides a foundation for artistic expression, education and research that will expand with new visual assets. Therefore, the next step of the development is focused on integration of the visual assets in the database with motion sensing devices such as Kinect (Microsoft, 2010).

One of the intentions of this research is to raise the importance of emotions in connection to digital worlds by providing the open, relational systems of the database as a tool for future use in the augmentation of whole-body movement and gesture. This concept incorporates time-based media replayed for the user/spectator in real time, and allows for an interactive synergy and integration between physical movement via Kinect (Microsoft, 2010) and the digital database that serves as a comparative model for emotive movement detection. This kind of environment could provide a platform for the exploration of emotional expressions and with this render another perspective on emotion explored from the somatic point of view. In order to extend the database with new assets of emotions created by the users, software that collects, compares and sorts the new material needs to be developed to expand the database in collaboration with programmers and software developers. By integrating Kinect with the database, new information and additional whole-body datasets can be added to the existing material, extending the database with new sets of emotions.

In pursuit of this idea a network of collaborators has been established in order to build cross-disciplinary partnerships and hopefully a research environment that focuses on how new assets could be collected from Kinect (Microsoft, 2010) as input created by the database users.

As investigations on programming solutions had already taken place during the doctoral studies, one of the suggestions that arose from the first meeting at the Computer Science Department at the University of Dundee, Scotland, U.K. was to establish a framework for future cooperation. As a result, the material for the database, 76 videos representing 4 emotions; anger, fear joy and sadness were discussed in order to find possible synergies with ongoing undergraduate and postgraduate student projects.
Similarly, interest in the PTM database as potential for future applications arose after a

presentation of the PTM project at a research meeting at Uppsala University / Gotland Campus, Sweden. Both professors responsible for the Convergent Media Lab, Steven Bachelder and Masayuki Nakajima were interested in experiments with the database as reference material for use with optical devices as a part of a future research project.

In the field of the creative arts, the PTM database content is used for experimentation purposes by visual artist Ioan Maria Stacewicz from Edinburgh Hacklab (2010) in the context of new media art, physical computing and AV performances for Kinect (Microsoft, 2010) as an input interface utilising *Processing* software (Processing Foundation, 2001).

The PTM is also used in an experimental project in cooperation with Carsten Orthbandt (2009) a game developer that also supports education and research at several European universities and schools. In this project, the database is used as a reference for movement translations from 2D to 3D space. The project aims to develop a system that could translate 2D moving image material based on xy coordinates to 3D data with an additional z depth coordinate. The intention of this project is to add supplementary information for 3D space to the PTM database.

As a teacher in the Game Department at Uppsala University, Sweden, I intend to implement the PTM database, movement/posture visualisations, and previously described pedagogical tools as part of the educational material in my coursework and lecturing. The initial focus would mainly be in those courses dedicated to animation and character development for games. Similarly, the material collected through the contextual research will be reworked and published as a set of tutorials for games design and graphics students. Both the database and published material will also be employed during the DAMA workshops that have become a part of Uppsala University's Nordplus international exchange network.

The issue and importance of human expressions as an integral part of communication processes within digital environments, was one of the essential motives for this research. Therefore, I will continue the research in order to extend the database in terms of emotional expressions and their socio-cultural background. The first steps in this direction are recounted in the next section. A list of the academic publications and conferences asociated with this research is also provided in Appendix N.

6.4 Summary and Future Work

6.4.1 Summary

Throughout the research, a holistic approach is applied that has its origins in phenomenology, reflecting a phenomenological approach to human perception in a spectrum of four "existentials": *spatiality*, *corporeality*, *temporality* and *relationality* (Van Manen, 1990). The aim of this approach is to transform this view to human interaction with digital content in which the whole human entity is considered as a component part of digital content development. In practice, this has been manifest during all stages of the database development and workshops and concludes with visual assets of movement-based expressive content. From this perspective, using a database format and quantitative and visual data, I set out to present the visual properties of four emotions: anger, fear, joy and sadness. The ontology of these emotions is identified by shape, space volume, expression readability and intensity, sequential movement over time and correlation data where visual similarities and differences are presented in printed chart form. The basic emotions chosen are founded on the classification of emotions and corresponding colour schemes as defined by Plutchik's *Psychoevolutionary Theory of Basic Emotions* (1980) and his *Colour Wheel of Emotions* (1980).

The PTM archive is an online database that provides visual properties of expressed emotion, as epistemic objects available for future development and explorations in the context of art, education and research. This holistic strategy is based on an ontological approach to the four lived worlds; *spatiality, corporeality, temporality, relationality*, (Van Manen, 1990) and resulted in the production of assets of the visual properties of emotion. The spatiality of emotional expression is described by xy coordinates contained in visual charts. Corporeality is visualised by silhouettes in motion based on the documentation of whole-body movement and gesture of 19 participants. Chronophotographic charts of movement timelines, and charts visualising the quantity of motion in relation to movement and time are applied to movement temporality. The community/relationality is visualised by the relationships among emotions and explored through gesture expressiveness and their associated communicative qualities. Both qualities are visualised in the database by Emotion Recognition Graphs and external to the database by the Periodic Table of Movements chart and X-ray series of the four emotions; anger, fear, joy and sadness. Consistent with this concept, the categorisation of movement corresponds to the metaphor of the Periodic Table of Elements, based on more philosophical reflections. Creating a foundation for a Periodic Table of Movements became partly a holistic statement, encompassing the concept of relationality grounded in phenomenology. Additionally, it fulfilled my personal need to position the human body and its emotional expressiveness in a different context, i.e. through a visual model based on quantitative and qualitative data, which encapsulates this research.

A substantial portion of this thesis is devoted to defining emotions, beyond the semantics of written words, using only the documentation of body movements and graphs. It is an attempt to explicate emotions using movement patterns collected as visual "footprints", in the form of silhouettes and graphs contained in a database to provide a future platform for the analysis of expressive movement and gesture.

The purpose of this archive is to serve as a tool for education and as a research resource within the context of physical movement representations in digital and game environments therefore primarily directed towards students and teachers in game design and graphics. However, the structure of the database provides material that is applicable and can be used, reused and explored in future studies and research across various fields of knowledge including; performance art, dance, art and design, the social sciences and computer science. The evaluation of methods and techniques via the contextual review supports my proposal that the continued mapping, and analysis of body language, will prove useful for numerous future applications, enhancing communication, creative output, and contributing to our quality of life.

The database is already used in education for game design and graphics as a pedagogical tool during my lectures in animation and character development in order to incorporate emotive expressions in games. However, as an open database available online, it provides an environment for other educators for exploration and research. The visual assets collected in the database provide creative possibilities for performance artists and researchers to use these resources in various combinations for research and the production of artworks. This can also be achieved in real-time and online, where the narrative values of collected expressions as visual assets can provide new ways of looking at embodied emotion as a powerful tool of communication that we all share.

This project-based study is a prelude to further research. I hope that that database and the collected visual assets will stimulate more studies on the fascinating topic of embodied emotion. I look forward to encountering new artistic and scientific explorations, methodologies, and new techniques in a wider variety of digital and real-world settings.

6.4.2 Future Work

In terms of future development, the Periodic Table of Movements exemplifies a possible method of distinguishing characteristic expressions for specific emotions and their relationality in terms of whole-body movement and posture. The database together with the *PTM System and Database Infographics; A Proposal for further development of PTM database with movement sensing devices* (Appendix D), provide a point of departure for future interactive applications and comparative systems for movement recognition via interfaces such as Kinect (Microsoft, 2010).

Current technological interface enhancements and real-time data aquisition capabilities provide new possibilities for database developments. Both the contextual review and the evaluation of methods and techniques support the proposal that the continued mapping, and analysis of body language, will prove useful in numerous future applications, enhancing communication, creative output, and contributing to our quality of life. The rapid development of technology has introduced sophisticated software and hardware into widespread general use, and at affordable prices, contributing to media democratisation and creativity. The need for natural human-computer interaction opens new avenues for the development of natural user interfaces (NUI). Microsoft's Kinect motion sensing interface is enabling the sophisticated use of movement and gesture rocognition as input material as well as for audio-visual feedback, exemplifying body movement used to interact with computing devices.

Looking closely at what the PTM database could contribute to the progressive development of physical games and digital art, we can hypothetically presume that, if the indexed data, as a set of emotional corporeal embodiments, is to be rendered into a structure readable by computers, then computers, by using comparative database systems, should be able to "read" human emotions. In practice, this indicates that we could create “emotionally responsive” applications. In art and performance art, it could create the possibilities of closer interaction with the audience, where the "digital", layered on the real world could create new scenarios working both as a mood amplifier and as a provocation factor. In game development, it may open up the option of developing movement reactive avatars as well as characters based on self-learning artificial intelligence (AI), with the capability of identifying player's emotional moods.

One of the future innovations of the PTM database will focus on software development aimed at connecting the PTM to optical motion recognition devices in order to track emotive movement trajectories of the user. In this design, the database will function as a movement-path reference and comparison system for gestures. During a registration process, user movements captured via a movement-sensing device will be compared and associated with those previously stored in the database as bitmap data, representing each of the postures. In this process, the movement data will be recorded, categorised, tagged and sorted by the name of the identified emotion. This way, the input data received will become a trigger/handler generating a response action from the game engine or any other application that uses the PTM reference system. The possibilities of what the output “action” could be are numerous, e.g. controlling an avatar, a colour composition, or an auditory arrangement to name a few. The premise of any feedback generated by the output is that it should connect with the sensations and the perceptions of the human body, and provide a representation of emotion easily recognisable by the user.
The system that contains the main elements described above is illustrated by the diagram in Appendix D: *PTM System and Database Infographics; a Proposal for further development of the PTM database with movement sensing devices*.

In the development of potential research areas, there are a variety of studies related to human body movement as well as emotive expressions where the PTM database could be applied. During the contextual review, a cartography of the related knowledge terrain was reported and presented in Appendix C: *Cross-disciplinary Knowledge Map.* The diagram illustrates both the knowledge fields researched as well as possible future application areas related to the PTM database.

Therefore, in terms of future development, a separate feature planned is the use of the database content, together with Kinect (Microsoft, 2010) to explore natural user interfaces as support for movement related feedback for games and real-time performance. This is based on comparative methods where movement data from Kinect could be categorised in association with the database. The system and approach are illustrated in Appendix D *PTM System And Database Infographics; A Proposal For Further Development of PTM Database With Movement Sensing Devices* as an infographic diagram based on my studies during the first phase of the doctoral research that focused on Computer Vision. This feature could extend the use of the PTM library for the research on movement based content for computer games.

The development of the database and Kinect (Microsoft, 2010) provides an opportunity to collect more data from future users, expanding the database with new emotive expressions. The development of the PTM toolset and the analysis of the visual properties of emotion were developed in relation to body shape (corporeality), time (temporality) and two-dimensional space (spatiality). The communicative qualities of gestures (community/relationality) were partly investigated via an online questionnaire but not fully addressed in the database structure due to the lack of real-time input from the users. Although the relationality, represented by the phenomenological inquiry as the “lived other” and referred to in the context of embodied emotion to gesture, the body’s movement and its position, it only has meaning in the context of a dialogue with others. The term “inter-corporeality” coined by Merleau-Ponty (1962) refers to this phenomenon of visual communication between bodies. This concept is important for the archive as a research tool; however, the development of personal data included in the database construction was beyond the scope of this research.

Consequently, in future developments, users could contribute to the PTM database with contextual information. As a result, in emphasising human emotion as a contextual phenomenon, the construction of the database and visualisations should include the possibility of adding external information supplied by the users. This valuable feature of the database could provide contextual samples for research on emotions in virtual environments and is directly related to how we perceive emotions expressed by others. A feature that refers to an ethnography of virtual emotion, would allow users to contribute to an evaluation of the readability of expressions, together with the inclusion of comments and personal information (age, gender, occupation and geographic origin). Additionally, the ability to evaluate differences between bodily expressions within the

digital environment and in real life could provide helpful information.
This approach reflects the socio-cultural aspect of emotion, however, the interpersonal exchange of body language as “inter-corporeality” is based on gesture, i.e. the body’s movement and its position that has meaning in the context of others, acted and interpreted in a dialogue. Emotion as described in this context by Crossley (1995) and Merleau-Ponty (1971) is what makes our gestures, postures, facial expressions and spoken words perceivable by others. In this context, the visual input data received from Kinect, as previously described, provides a tool that makes it possible to use the expressions contained in the database in a dialogue with the user's expressions. These could also could be simultaneously recorded as complementary data to each of the files in the database.

Accordingly, in the context of relational models of human behaviour and based on the PTM's existing material and its narrative values, my intention is to develop a relational model of expressions using database queries by combining videos to form a dialogue between two different emotive movements. This idea is based on the movement's choreographic value per se, and builds on the variety of expressions contained in the videos stored in the database. This feature could extend the database with an interesting application that could be both a creative and a research tool, allowing exploration of the narrative impact among the different combinations of emotive-expressions.

The priority for any future development work is to extend the database making it possible for students, artists and researchers to publish their own data and interpretations of data contained in the database. Any new data could be collected both via Kinect (Microsoft, 2010) and by uploading the user's own interpretations of existing content. In considering the material contained in the database, the visual data could be used in a broad variety of ways where the visual assets could be transformed through new interpretations, and for a range of other purposes. For example, as demonstrated in section 4.5.7 *X-Ray of Emotional Kinesphere*, the expressions of emotion contained in the database are explored in terms of volume as an outline of ‘personal space’ (Laban, 1950; Schlemmer, 1928a).

In general, the objective of the database is to provide possible, visual reference points of embodied emotion without determining any final or fixed norms, maintaining the idea of a research ‘sandbox’ where explorations and inspiration could take place. In an attempt to understand how emotional expressions reflect today's society and the cultural influences of the media, the database should integrate scientific and non-scientific knowledge domains by supporting existing metaphors and interpretations of embodied emotion.

In terms of the additional features of the PTM database, at the time of writing, the issue of the missing data for capturing movement in 3D space has been identified as an additional project. The aim is to develop a tool that translates existing 2D video material into movement trajectories in 3D visual space. This goal can be achieved with the creation of an additional tool, implemented in the database, that calculates the appropriate z coordinates, enabling translation of videos ‘on the fly’ into movements represented in 3D space, a feature that was partly explored in section 5.1.9 *X-Ray of Emotional Kinesphere.*

The novel visualisation methods provide for both artists and researchers a platform for experimentation and new ways of presenting research findings and explorations of scientific visualisation methods in the arts. The visual qualities of emotion are provided as epistemic objects open for future development through cross-disciplinary cooperation. Concerning the development of movement recognition technology, I propose that additional tools and methods for the research of corporeal emotional expressions are needed. As the basis for this statement, the PTM database is one of many possible approaches for embodied, emotional expression analyses, providing a platform for research and the future development of movement based interfaces for animation, where expressive whole body movement and gestures of digital characters could contribute to the development of narratives in virtual worlds with the emphasis on games.

In summary, the journey is still unfolding as this research in practice will continue to evolve over time, beyond doctoral studies, searching for answers, since answers always generate more questions, creating a continuous chain of enquiry.

Appendix A

Shadow Dance:

Installation and discussion on proposed solutions for embodied games through cross-disciplinary workshops within an educational context.

Duncan of *Jordanstone College of Art and Design*, University of Dundee, Scotland, UK, Authors: Iwona Hrynczenko, Nigel Johnson, Gair Dunlop.

Keywords:
Embodiment in new technologies, dance technology, physical games, expressive gesture, pedagogical tools, interdisciplinary collaboration.

Abstract
This paper argues the issue of embodiment and gesture in games, the aesthetics of movement from the phenomenological point of view, and suggests a framework proposal for DAMA, a Dance and Media Art Network interdisciplinary network project, which integrates students and teachers from art schools and universities within the European Nordic and Baltic regions. This argument is supported by documentation of *Shadow Dance* installation that presents an interactive tool for corporeal expressions, based on real-time movement capture, an open source and visual programming environment (Pure Data), all integrated within a web environment (see Acknowledgments). The aim of this installation is to propose a different perspective based on corporeal movement's aesthetics via subjective expressions. It is one of the action points for the game development process, during interdisciplinary workshops, proposing content based on traditions in dance and physical theatre and encouraging the notions of presence and creative use of whole body movements across digital space and especially within physical games.

Context

The following work references the aesthetics of the physical body within new technologies, as widely argued by Broadhurst (2007) and to the personal perspective built on long-term experience working with students within the Game Development Department at Gotland University and background in Polish Physical Theatre based on Grotowski's methods. *Shadow Dance* is a method borrowed from physical theatre and translated into a digital interactive tool and installation with the same name, which took place in September 2009, at the Visual Research Centre/DCA (Dundee Contemporary Arts). It is an attempt to obtain an active response from the audience/participant for the visual stimulation tasks through the mirrored movement of oneself, such as a visual confrontation that opens neurocognitive channels to self-discovery of bodily-amplified empathy (Freedberg & Gallese, 2007). The installation is based on motion recognition using a web camera as input. The output supports the subjective perspective, by mirroring movement traced in real time, and is assisted by immediate feedback trough visual movement collections, encouraging experimentation and reflection. Emerging development of gesture-based technology is opening doors for a paradigm change in the way we perceive at the human body, the physical aspects of corporeal movement and at the expressive gesture. Camuri (2002) situates expressive gesture in the artistic context, such as performing arts, as a container of information based on emotions. 'Expressive gesture is the responsible of the communication of information that we call *expressive content*. Expressive content is different and in most cases independent from, even if often superimposed to, possible denotative meaning. Expressive content concerns aspects related to feelings, moods, affect, intensity of emotional experience.'

This paper refer to the expressive gesture in terms of Natural User Interfaces (NUI) and to expressive content such as user input as well as in terms of the game content, such the expressive gesture of avatars. *Shadow Dance* is a part of PhD research project; Periodic Table of Movements that is intended to collect and classify human corporeal movements according to emotions.

The following refers to two different pools of recent development: Synchronous Objects and Natal, both projects are based on human body movements and illustrate possibilities for new platforms for future developments based on expressive content.

Synchronous Objects explain and explore choreographic structures of William Forsythe through visual communication techniques build on data visualization tools for capturing, analysing, reimagining and presenting movement of dancers in terms of volume and space. (http://synchronousobjects.osu.edu/). This, according to Forsythe (2009) is to make dance and choreography accessible and understandable for the broad public. This project was collaboration with Ohio State University, Advanced Computing Centre for the Arts and Design and The Department of Dance.

The game industry accelerated development of gesture responsive applications built on infrared and optical tracking systems and full-body 3D motion capture. Microsoft's project Natal for Kinect, the Xbox 360 video game platform uses advanced futures, which turns human body in to an interface using full-body gestures, facial expressions and sonic localisation as input. In this case game industry is a driving factor in terms of development of new sensing technologies.

Based on recent technical developments, the following is posed. Could emotions be translated into numbers that were accessible for computational systems without a loss of intuitive presence?

Intention

The intention of this project is to change the perspective on the physical body from one of 'object' to one of 'subject' in terms of bodily experience. During the industrial revolution, the human body was presumed to adapt as a component of the industrial process. This perception continued on into postmodern cultures during the development of digital environments, along with human-computer interaction models, and automatically prepared the foundation for today's gaming culture. Advances in technical developments, should allow us to take into account a more holistic human approach, and therefore it is important to discuss how to reduce these knowledge gaps.

The background to this discussion is the issue of empathy and kinaesthetic empathy in the digital environment, as in games. Empathy could be considered to be an "interface" to ourselves that connects us to the collective consciousness of the human species. Therefore, it is important to ensure that the emotional presence or subtlety of movement is not lost within the system's interpretation and translation of that movement. Munster (2006, p.26) debates a corporeal virtual experience and uses the term "reconfigured bodily experience" in describing a new level of experience as a "new logic in the non-

liner sense.” Further, the ‘digital embodiment’ is a process in which “...individual bodies engage with digital codes to produce new and different sensations and affects” in the process of “reclaiming” the digital space and technology.
However, from a performance art phenomenological perspective, some questions arise concerning how a game's content could look if games were also tools used to increase human perception based on human corporeal movement and expressive content. Could the past century's knowledge, derived from pioneering performance and theatre work by Stanislavsky (1863 -1938), Gurdjieff (1866-1949), Meyerhold (1874-1940), Schlemmer (1888- 1943), Lecoq (1921 -1999) and Grotowski (1933 -1999) be transferred into two and three-dimensional digital games? Many names could be added here in terms of choreography, dance and body-centred knowledge. However, this question may not be answered through analyses on why the Cartesian view of the human body dominates the gaming world, but rather via knowledge exchange among different art cultures through collaborative interdisciplinary practices beginning at an educational level.


Figure A.0.1 Shadow Dance installation. Movement mirror on screen, Hrynczenko, 2009.

Shadow Dance Interactive Installation as a Pedagogical Tool.

Performance art disciplines have the privilege and experience to use the body as a poetic tool in exploring the boundaries between the body, on the one hand, and time, space and human communication, on the other. This exploration related to phenomenology and the four existentials formulated by Max van Manen (1990), “lived space (spatiality), lived body (corporeality), lived time (temporality), and lived human relation (relationality or communality)” (p. 102).

It is necessary to consider this knowledge when constructing simulations in the virtual world, since the value of subjective physical experience is important when constructing Natural User Interface (NUI) and motion based content. Cooperation between Performance Art, Media Art and Computer Sciences is inevitable and necessary in order to support development of both. How this different knowledge cultures could build a common knowledge base with common semiotics? The first common denominator worth considering is the fact that this knowledge disciplines, unfortunately often positioned as opposites, possess the notion of play. Play, as a conceptual space, according to Huizinga (1949), is a natural element of human culture.

In case of *Shadow Dance*, as artefact it provides pedagogical tools build on simple game strategy, which could be classified in the area of Serious Games. Serious Games are in the first place, pedagogical or training tools that are not considered entertainment but may entertain to achieve educational goals. In the context of this project, the aim is to extend the notion of body movement and use the provided documentation for further development of ideas. This application was built using Pure Data and is based on webcam input, which produces several layers of captured movements projected on each other, thus making it possible to follow the movement trace spectrum in real time. Participants use their body as the interface to influence the visual information projected on the screen. Graphical representations of these movements, viewed as shadows are collected from the camera and projected onto the screen. However, physical dialogue between participants and the projection is needed to achieve new graphical effects. In this way, movements drawn on the screen build patterns that extend body parts from its joints. (figure 2,3 and 4).

Figure A.0.2 Shadow Dance installation, Movement patterns; Slow movement, Hrynczenko, 2009.


Figure A.0.3 Shadow Dance installation, Movement patterns; Fast movement, Hrynczenko, 2009.

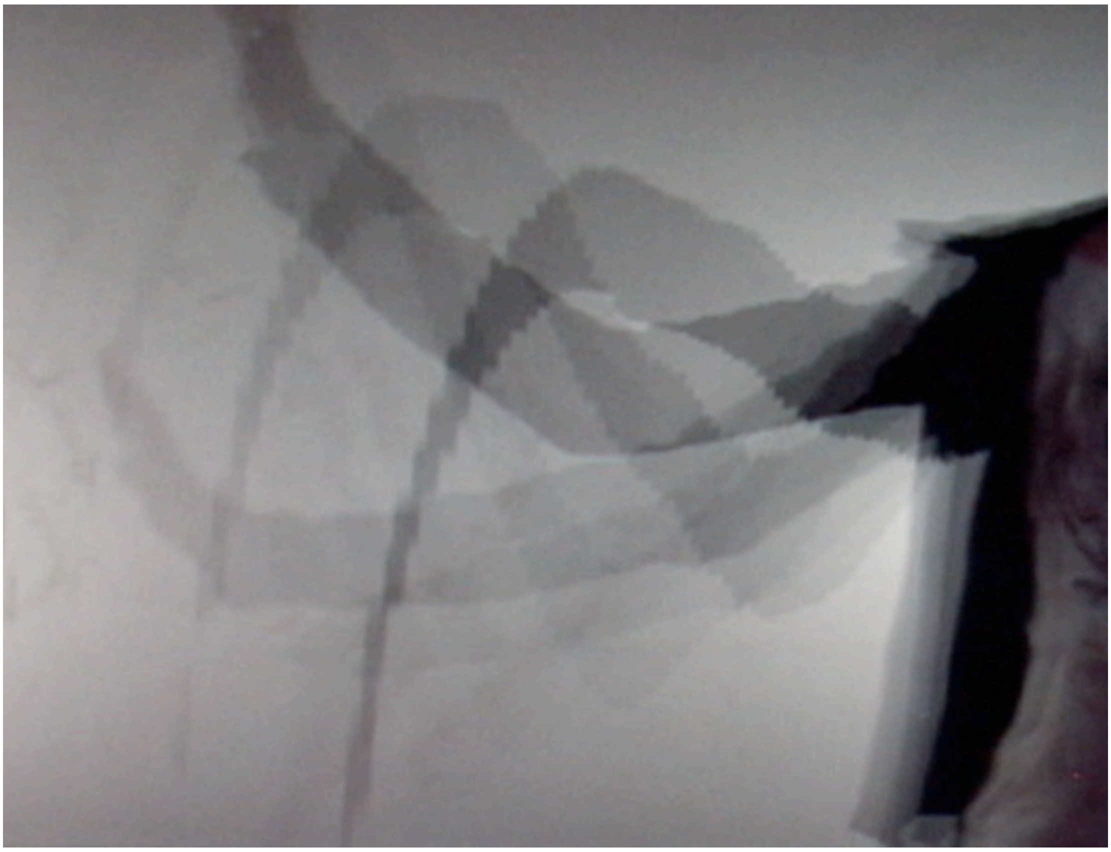



Figure A.0.4 Shadow Dance installation, Movement patterns; Very fast movement, Hrynczenko, 2009.

Patterns size depends on gestural expression and intensity illustrated here in the schematic action flowchart (figure 5). Possibility to extend the virtual body opens a kinaesthetic consciousness for the participants. Dependent of participants movement intensity, the output is stored on a website as movements key frames using a database built on XML and PHP scripting language (figure 6). Movement representations are replayed for the participants as visual collections inspired by the works of Muybridge (1830-1904) and Marey (1830- 1904).

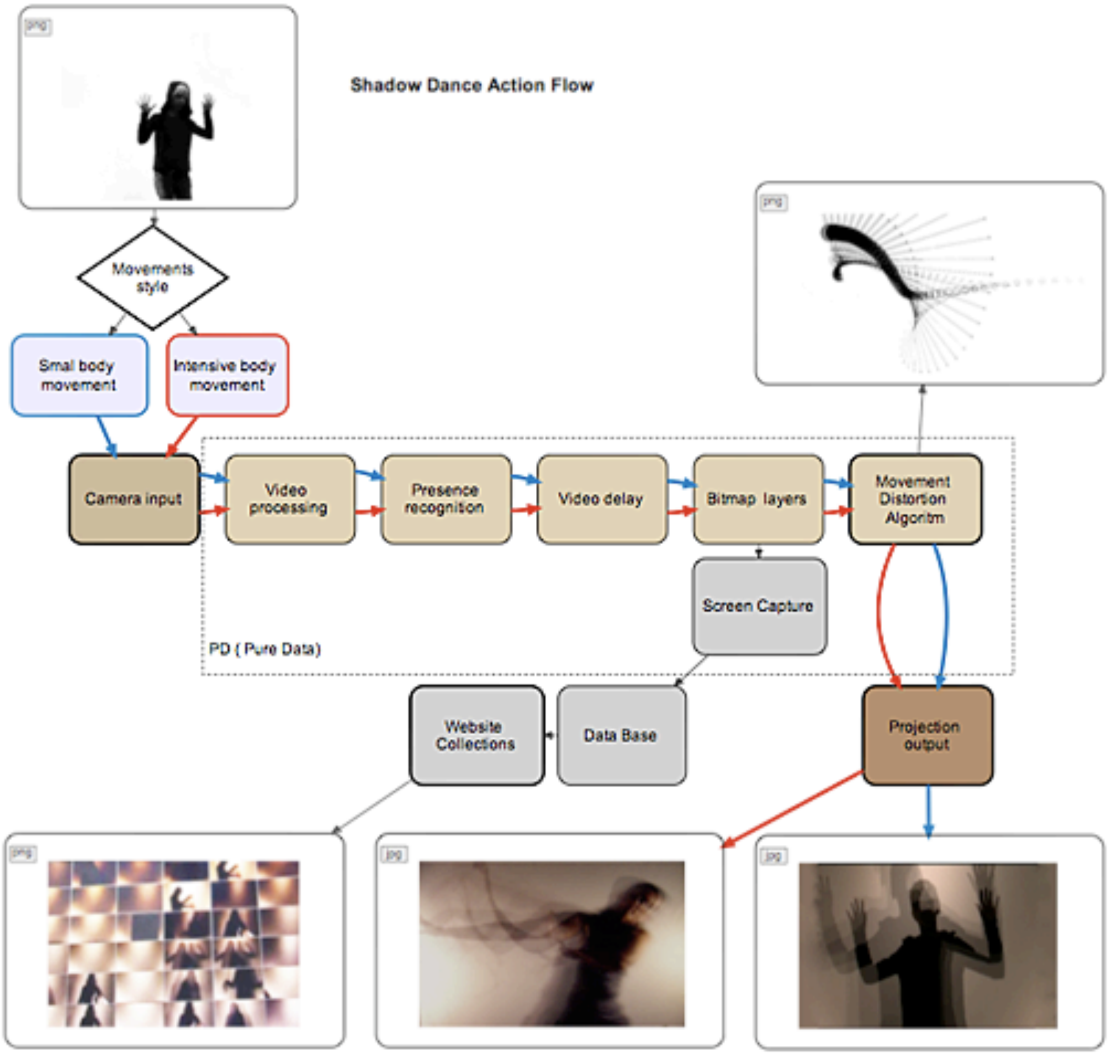


Figure A.0.5 Shadow Dance; Action Flowchart, Hrynczenko, 2009.

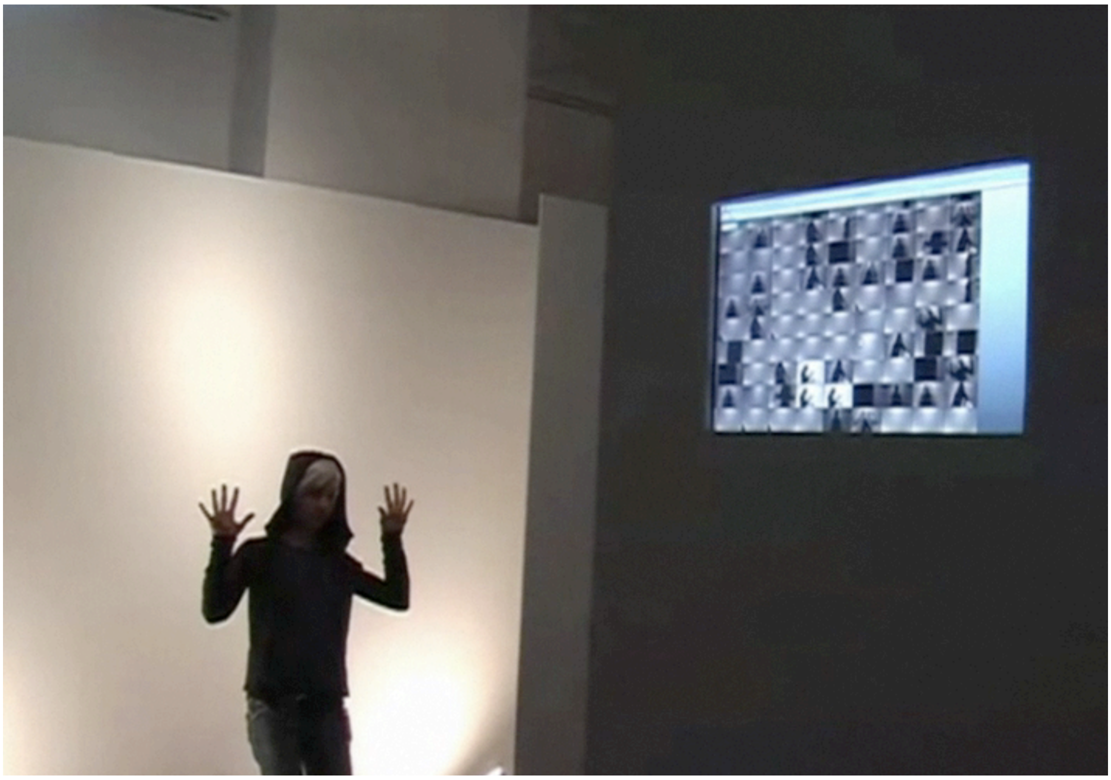


Figure A.0.6 Shadow Dance installation; Key frames collection on the website as real-time publishing, Hrynczenko, 2009.

Conclusion

Shadow Dance invite participants to explore body movement in two different ways. Firstly to explore in playful way their own body in motion as an expressive movement, inviting to experimentations gives an opportunity to connect physical movement with visual experience, and opening the possibility to explore and analyse the visual movement trace via a virtual mirror. These develop deeper understanding of the movement's physical process, also movement's relation to anatomy, mechanics of specific joints of human body and personal kinaesthetic perception. Secondly the documented movements stored on the website can be used as *mocaps* for further movement analyses, also as sketches when corporeal movement consciously reflected could be useful in character development in games and possible to reply in *Mocap capture studio*.

In conclusion I propose the use of interactive artefacts, in this case *Shadow Dance* installation, as tool in education and research. The fact that these artefacts are simple games provokes the next conclusion. The areas of expressive gesture knowledge can be extended using playful methods, thus preserving the authenticity of movement's intentions. This is reflected as a framework proposal for the 2011 DAMA Network meeting based on experience as a participating teacher during two previous workshops: Rovaniemi, Finland, 2007, and Tallinn, Estonia, 2010.

Framework proposal

The Dance and Media Art Network (DAMA), founded by EU North Plus, is an interdisciplinary network project that integrates students and teachers from art schools and universities within the European Nordic and Baltic regions. Beginning in 2005, the network organised several workshops in Reykjavik Island, Visby, Gotland, Sweden, Rovaniemi and Turku in Finland, and Tallinn, Estonia. All workshops were project based and built on the cooperation between dance and media students. During those workshops several issues were revealed, such as the need for methods for interdisciplinary collaborations and interartistic ways of working as well as better understanding of the possibilities beyond student's subject-specific knowledge when working across disciplines (Knuutila, 2007).

Based on experience from cross-disciplinary workshops with DAMA, this practical, project-based knowledge exchange between students has given rise to many innovatory solutions, assembling core knowledge of their domain-specific skills (Knuutila, 2007). In conclusion, this paper considers action points for the proposed interdisciplinary workshop DAMA 2011 at Gotland University in Sweden, encompassing areas such as physical gaming, media arts, dance, urban planning, and game design. Based on pedagogical methods, the purpose is to provide students with a common ground in movement based on self-notion and game design. Further, this paper aiming to serve as a starting point for future discussions on the development of new knowledge exchange platforms in terms of cross disciplinary cooperation.

Proposed framework action points:

1) Physical exercises, such as movement sequences: goal-directed functional, expressive-emotional, parallel mirroring, abstract improvisations, rhythmical introvert, rhythmical extrovert, and communicative gestures in pairs.
2) Group trust exercises such as caring and touching, foaling, and catching.
3) Common semiotics for physical movement descriptions verbalized during the performed movement.
4) Analyses of the visual movement trace via a virtual mirror, *Shadow Dance*.
5) Simple character based live games using floor and urban space.
6) Dance with cameras (see body movement trough the camera in real-time).
7) Camera as a first person shooter (see the space through the camera in real-time).
8) Dancing, and running with blindfolded eyes.
9) *Mocap capture studio* exercises, crossing 3D space.
10) Laban Movement Analysis (LMA).
11) Game development theory.
13) Movement sensors.

Acknowledgments

Shadow Dance application was developed with help of (Pure Data programming) from Stacewicz, J., Donnarumma, M., & Allen, J. (2009) during Master year in Screendance at Duncan of *Jordanstone College of Art and Design*, University of Dundee, Scotland, UK, and exhibited 12-19 September 2009 at Visual Research Centre/ DCA (Dundee Contemporary Arts) Dundee. Contextual review available in Master Report (Hrynczenko, 2009).

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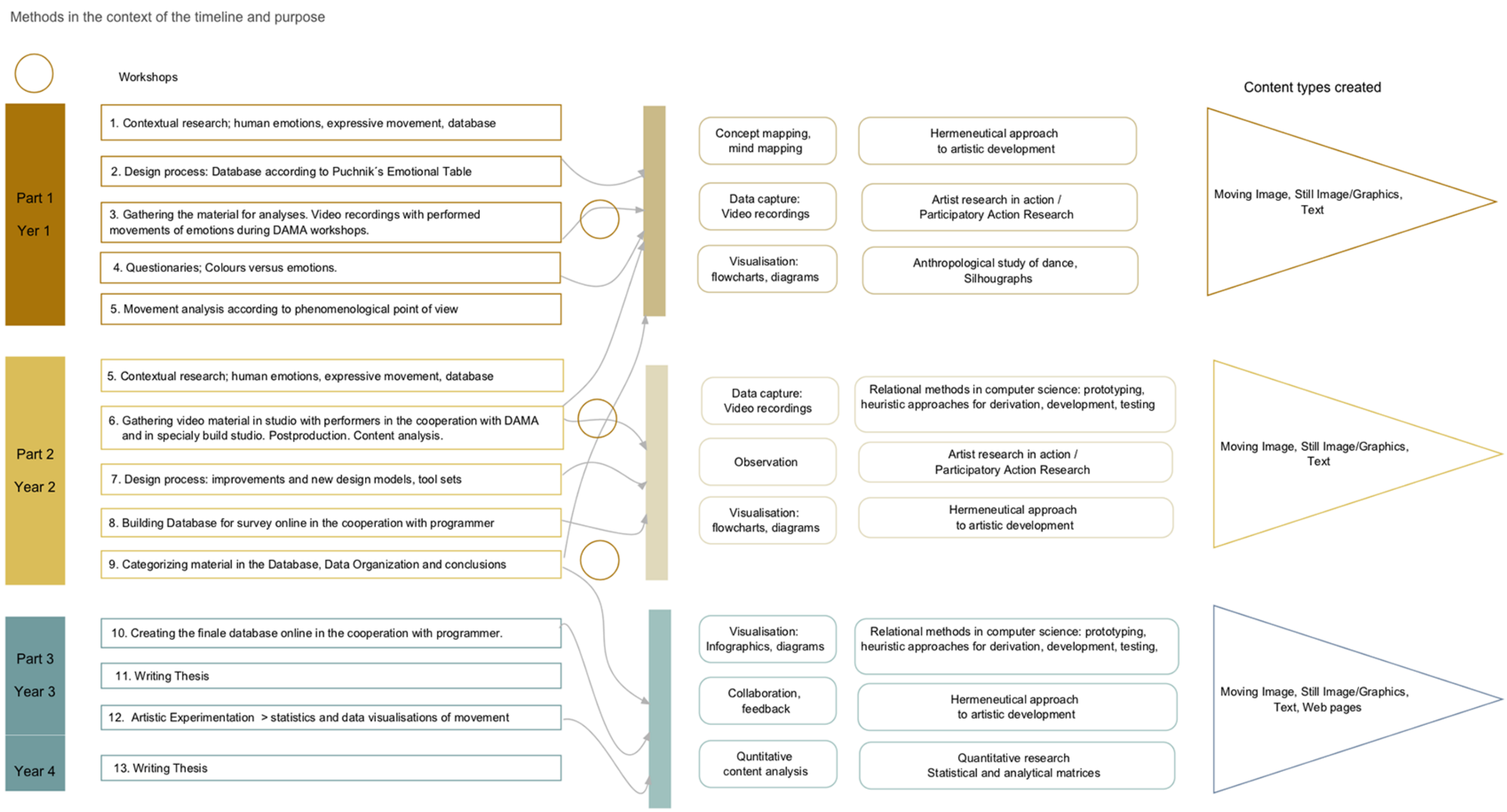
Appendix B

Methods in The Context of The Timeline and Purpose

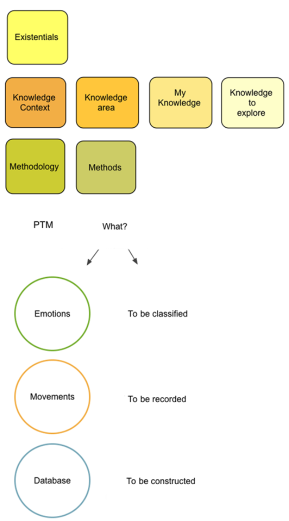

Methods in the context of the timeline and purpose
Workshops
Part 1
Yer 1
1. Contextual research; human emotions, expressive movement, database
2. Design process: Database according to Puchnik´s Emotional Table
3. Gathering the material for analyses. Video recordings with performed movements of emotions during DAMA workshops.
4. Questionaries; Colours versus emotions.
5. Movement analysis according to phenomenological point of view
Concept mapping, mind mapping
Data capture: Video recordings
Visualisation: flowcharts, diagrams
Hermeneutical approach to artistic development
Artist research in action / Participatory Action Research
Anthropological study of dance, Silhougraphs
Content types created
Moving Image, Still Image/Graphics, Text
Part 2
Year 2
5. Contextual research; human emotions, expressive movement, database
6. Gathering video material in studio with performers in the cooperation with DAMA and in specialy build studio. Postproduction. Content analysis.
7. Design process: improvements and new design models, tool sets
8. Building Database for survey online in the cooperation with programmer
9. Categorizing material in the Database, Data Organization and conclusions
Data capture: Video recordings
Observation
Visualisation: flowcharts, diagrams
Relational methods in computer science: prototyping, heuristic approaches for derivation, development, testing
Artist research in action / Participatory Action Research
Hermeneutical approach to artistic development
Moving Image, Still Image/Graphics, Text
Part 3
Year 3
Year 4
10. Creating the finale database online in the cooperation with programmer.
11. Writing Thesis
12. Artistic Experimentation > statistics and data visualisations of movement
13. Writing Thesis
Visualisation: Infographics, diagrams
Collaboration, feedback
Quntitative content analysis
Relational methods in computer science: prototyping, heuristic approaches for derivation, development, testing,
Hermeneutical approach to artistic development
Quantitative research Statistical and analytical matrices
Moving Image, Still Image/Graphics, Text, Web pages

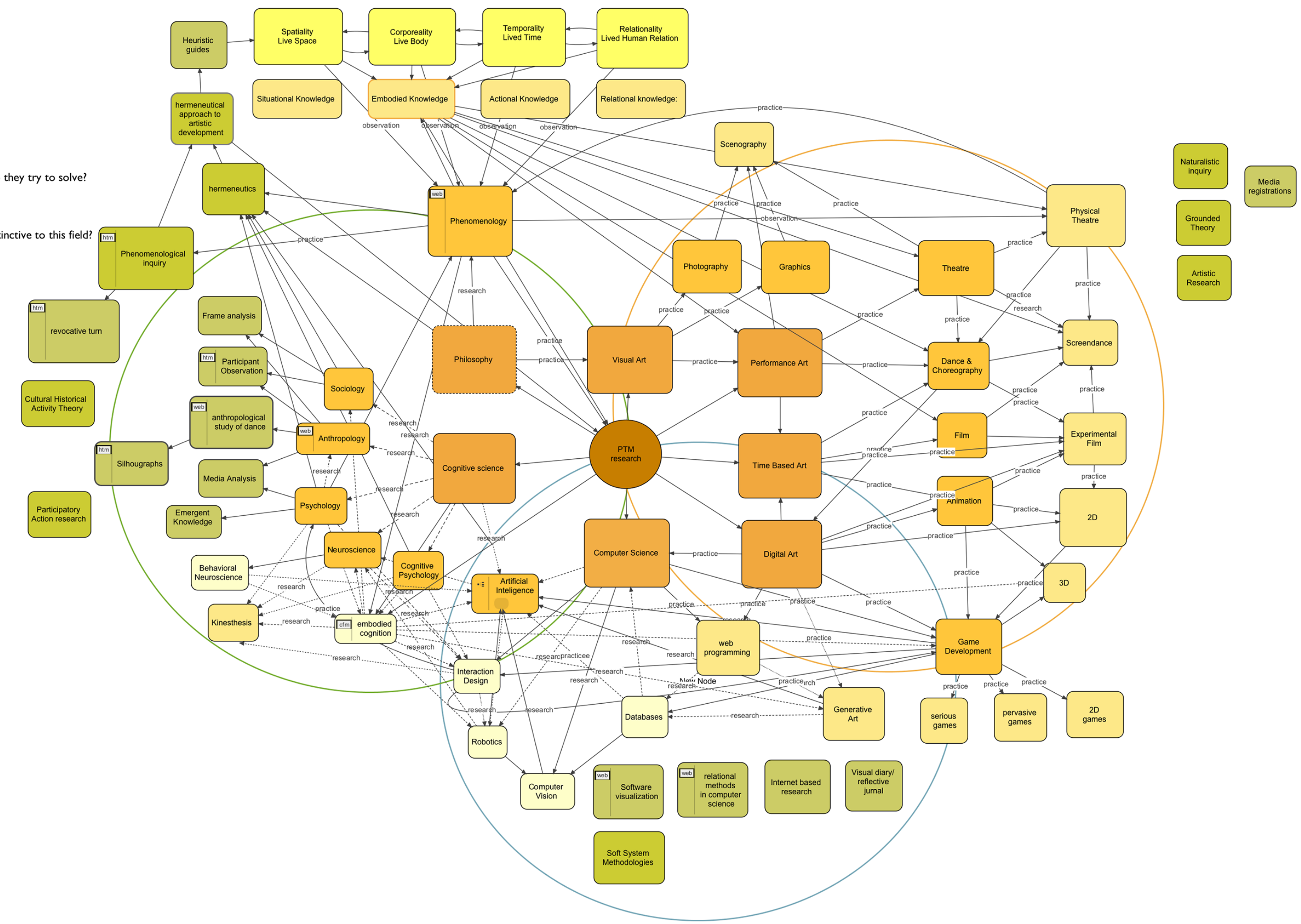
Appendix C

Cross-disciplinary Knowledge Map

PTM Cartography
Cross-disciplinary Knowledge Map

- How strong is my knowlage in this field?
- How this relates to my research?
- What are the most basic ideas, concepts or theories in this field?
- What viewpoint is fostered in this field?
- How this field affect my view of the world?
- What kinds of questions do they ask? What kinds of problems do they try to solve?
- What do professionals in this field take for granted or assume?
- What sorts of information or data do they gather?
- What types of methods they use?
- How do they go about gathering information in ways that are distinctive to this field?



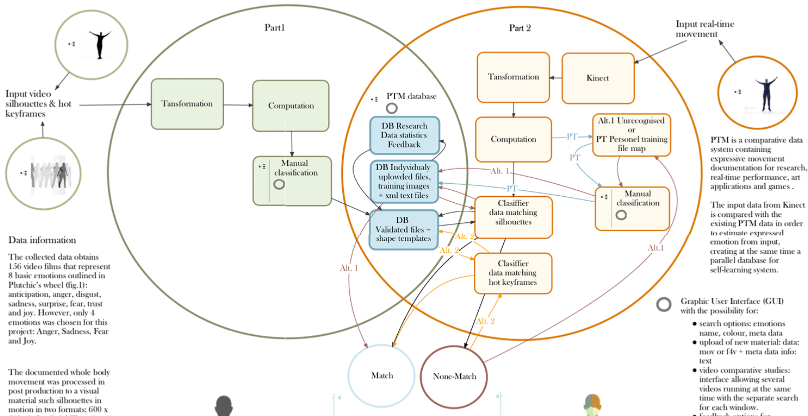


Appendix D

PTM System And Database Infographics;

A Proposal For Further Development of PTM Database With Movement Sensing Devices.

PTM System and Database



PTM is a comparative data system containing expressive movement documentation for research, real-time performance, art applications and games .

The input data from Kinect is compared with the existing PTM data in order to estimate expressed emotion from input, creating at the same time a parallel database for self-learning system.

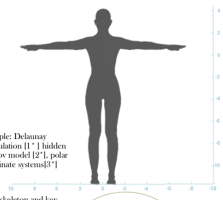
Graphic User Interface (GUI) with the possibility for:

- search options: emotions name, colour, meta data
- upload of new material: data: mov or f4v + meta data info: text
- video comparative studies: interface allowing several videos running at the same time with the separate search for each window.
- feedback options for database users: questionnaire: gender, age, geographical origin, comments.

Data information

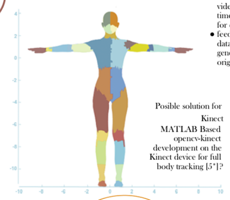
The collected data obtains 156 video films that represent 8 basic emotions outlined in Plutchic's wheel (fig.1): anticipation, anger, disgust, sadness, surprise, fear, trust and joy. However, only 4 emotions was chosen for this project: Anger, Sadness, Fear and Joy.

The documented whole body movement was processed in post production to a visual material such silhouettes in motion in two formats: 600 x 600 pix for QuickTime (mov) and 500 x 500 pix for Flash player 10 (f4v), with additional thumbnails 160 x 120 pix (png)..



Part 3 ?

If Match................

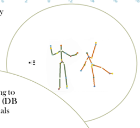


Posible solution for Kinect MATLAB Based opencv-kinect development on the Kinect device for full body tracking [5*]?

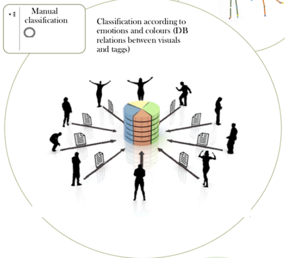
Data process information

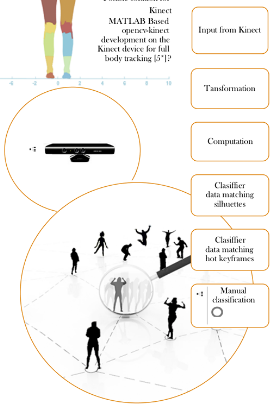
Tansformation — Example: Delaunay triangulation [1 *] hidden Markov model [2*], polar coordinate systems[3*]

Computation — Curve skeleton and key skeleton points or pattern recognition , silhouette histogram [4*]?



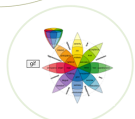
Manual classification — Classification according to emotions and colours (DB relations between visuals and taggs)





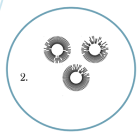
Possible output options based on emotion recognition

Plutchik's wheel of emotions based on colours v. emotions



1.

2.



3.

4.

3.

5.

1. In the performance, art and game design colour could function as a mood enhancer where background colours, lights and artefacts could be modified according to the gestures expressed on the stage, the art gallery or during the game-play. This interesting option can use the database's colour coding system.

2. The graphical visualizations of emotions and movements could be utilized both as info-graphics, and for the research purpose by empowering visual analysis of movements as real-time experience synchronizing movements with emotion as visual data prints and projections.

3. In dance or performance art i.e., as on the stage experience the combination of silhouettes comprised in the database together with movement/emotion recognition tools could augment the performative content through the projections of a new narrative elements such as for example responsive shadows or projected emotionally reactive actors/dancers, avatars.

4. In game design and development expressive movement, AI could be implemented in to the game engines as a different way of interacting with characters and environments, based on player's emotional expressions and self-learning agents.

5. With the further development of PTM a combination between movement and written text could augment research tools and artistic expressions merging them in to the artistic and scientific explorations. By extending the database with the mew material and number of emotions it could be achievable to accomplish the vision of Periodic Table of movements.

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Appendix E

Ethics Guidelines and Forms

1 Participant Information Sheet

Periodic Table of Movements (PTM): A reactive database in real-time performance

INVITATION TO TAKE PART IN A RESEARCH STUDY

You are being asked to take part in a research study, which aim is to document and analyse correlation of physical bodily expressions to emotions and colours for the research project; Periodic Table of Movements (PTM): A reactive database in real-time performance by Iwona Hrynczenko PhD student at the University of Dundee, College of Art, Science & Engineering, Duncan of Jordanstone College of Art & Design, supervised by Professor Nigel Johnson and Mr Gair Dunlup,

PURPOSE OF THE RESEARCH STUDY

This project will document and catalogue video samples of whole-body gestures as silhouettes in the purpose to study correlation between emotions, movement and colour perception for the computational analyses in the field of human computer interaction (HCI). As a finale test/presentation the silhouette projections will be used as a background in a real time performance.

TIME COMMITMENT

The study will require from the student/professional in the field of dance/theatre to perform in the front of recording camera eight different emotions: joy, trust, fear, surprise, sadness, disgust, anger, anticipation with in the time scoop of 30 seconds for each emotion, to be completed during 1 session. (WHO BENEFITS FROM THE RESEARCH) Participation in this research would benefit the development and research of new interfaces in field of Human Computer Interaction as well as studies of new methods in real-time performance.

TERMINATION OF PARTICIPATION

You may decide to stop being a part of the research study at any time without explanation. We will still appreciate your contribution. Your decision will not affect or will not have any further consequences on the parallel ongoing workshop or dance/performance exercises.

RISKS
There are no known risks for you in this study.

COST, REIMBURSEMENT AND COMPENSATION

Your participation in this study is voluntary and will not involve any payment. Therefore based on this condition, you have free choice to not participate in the session. Your decision will not affect or will not have any further consequences on the parallel ongoing workshop or dance/theatre exercises.

CONFIDENTIALITY/ANONYMITY

The data we collect do not contain any personal information about you except (SPECIFY) gender, age, nationality, and professional/educational field.
No one will link the data you provided to your identity and name, however for the finale exhibition/performance your name will be accredited if you wish so in the finale credit list, therefore if you wish so, pleas sign your name on the separate provided credit list. The credit list is not connected to the collected personal data in the questionnaire.

The recorded video material will be in postproduction transformed to silhouettes /shapes and by this will remove the personal characteristics of participants. The collected data will be used as a support for computational processes and the projected silhouettes will be used as a background I real time performance. Some of silhouettes' will be used as a documentation material in research presentations or publications and also as a material for an on line questionnaire.

FOR FURTHER INFORMATION ABOUT THIS RESEARCH STUDY

(NAME) Iwona Hrynczenko will be glad to answer your questions about this study at any time by e/mail.

If you want to find out about the final results of this study, you may contact Iwona Hrynczenko by e-mail: iwona.hrynczenko@hgo.se or I.Hrynczenko@dundee.ac.uk

Iwona Hrynczenko

Address: Gotland University

Institution for Game Design, Technology and Learning

Cramérgatan 3

621 67 Visby

Sweden

The Academic Supervisor for this project is Nigel Johnson; n.m.johnson@dundee.ac.uk

The Research Ethics Sub-Committee of the Research Committee of Duncan of Jordanstone College of Art & Design at the University of Dundee has reviewed and approved this research study.

2 Postgraduate Research Ethics Approval Form

Duncan of Jordanstone College of Art & Design, University of Dundee

Postgraduate Research Ethics Approval Form

SECTION A – to be completed by Student
1. Degree/ Programme title (underline as appropriate): **Mphil** **PhD**
2. Project Title: Periodic Table of Movements (PTM): Reactive Database in real time performance **On line survey: Evaluation of expressive movement recorded as silhouettes in motion.**
3. a) Name of Student working on this project: Iwona Hrynczenko **b) Email address of student: I.Hrynczenko@dundee.ac.uk** **c) Name of Supervisor: Nigel Johnson** **d) Email address of Supervisor:** n.m.johnson@dundee.ac.uk
4. a) Names of any other collaborators on the project: Blazej Pindelski , University of Edinburgh School of Informatics, Actual Analytics research (in this project: on line database programming)
5. Expected duration of project: From: 12/03/15 to: 12/05/20
6. Briefly describe the project: The project aims to validate and label previously recorded expressive gestures as a visual artefact in the form of silhouettes / shapes. This in order to study the relationship between bodily expression of emotions as a framework of the PhD project: Periodic movements (PTM), a reactive database in real-time performance. The final objective of this research is to build a digital database, an anthology of "expressive gestures. "Expressive Gesture" is considered as a main non-verbal communication channel, particularly in the performing arts, it is not intended to refer to things or to support speech as in the traditional framework of natural gestures, but the information it contains and conveys is related to affective/emotional domain of the performative act. In the purpose to evaluate the reliability of silhouettes in motion as a visual representation of emotions, survey participants will be provided an on line questionnaire aimed to assess the participant, gender, age, geographical origin, professional/educational field, and the name of emotion they associate with provided video presenting silhouettes in motion.

7. Identify the particular ethical issues that may be raised by this project: Anonymity of the survey

The survey is anonymous. The record kept of participants' responses does not contain any identifying information about them. Participants will respond to a survey that used an identifying token to allow them to access the survey, however the identifying token is not kept with participants' responses. It is managed in a separate database, and will only be updated to indicate that participants have (or haven't) completed the survey. There will be no way of matching identification tokens with survey responses in this survey.

…2/

If your research involves human participants, please complete the following sections.

Declaration
I have read and understand the University of Dundee Guidelines for Ethical practices in research and the Duncan of Jordanstone Guidelines for Ethics involving Human Participants. I confirm that my research is in accordance with these guidelines.

Name (Research Student) Iwona Hrynczenko **Date** _12/02/20

Part A

The declaration above confirms that you will:

- Provide an information sheet to participants which describes the main procedures to participants in advance so that they are informed about what to expect;
- Tell participants that their participation is voluntary (both in information sheets and consent forms);
- Obtain written informed consent for participation and provide participants with a copy;
- Ask participants for their consent to being observed, should the research be observational;
- Ensure that participants are able to read and understand the participant information sheet;
- Tell participants that they may withdraw from the research at any time and for any reason;
- Give participants the option of omitting questions they do not want to answer if a questionnaire is used;
- Tell participants that their data will be treated with full confidentiality and that, if published, it will not be identifiable as theirs;
- Tell participants that all recordings, e.g. audio/video/photographs, will not be identifiable unless prior written permission has been given by the participants;
- Tell participants that data will be destroyed on completion of the project.

- Debrief participants at the end of their participation (give them a brief explanation of the study).

Part B

			Yes	No
1.	Will your project involve deliberately misleading participants in any way?			X
2.	Is there any risk of participants experiencing either physical or psychological stress or discomfort?			X
3.	Do participants fall into any of the following special groups? Note that you will also need to obtain Disclosure Scotland clearance when working with vulnerable people	Children (under 18 years of age)		X
		People with intellectual or communication difficulties		X
		People with age related disabilities such as dementia		X
		People engaged in illegal activities (e.g. drug taking.)		X
		Animals		X
		NHS patients		X

…/3

If you have ticked 'yes' to any of the questions above, you must provide the following information as a separate attachment:

a) Title of research project
b) Aims and objectives of the research
c) Description of methods to be used
d) Participants: recruitment methods, number of participants, age, gender, exclusion/inclusion criteria
e) Consent and participant information arrangements and debriefing
f) A concise statement of the ethical considerations raised by the project and how you intend to deal with them
g) Estimated start date and duration of the research
h) Supporting documentation e.g. Examples of a questionnaire, interview questions, tasks to be undertaken by participants etc. as appropriate.
i) Participant Information form
j) Participant Consent form
k) If external ethical approval has been granted, please attach approval letter

Part C

If you have ticked 'No' to all the questions in Part B above, you must attach the information in a) to k) above to this application and complete the box below.

I consider that this project has no significant ethical implications to be brought before the Ethics committee	Research Student signature

Give a brief description of participants and procedure (methods, activities to be used) in up to 150 words

The Interactive on-line survey is designed in 3 parts. The firs page will describe the study and invite participants to complete the QA. Additional text will explain that the data they supply is anonymised by the system (with the explanation how it is preceded) and that the participation in this survey is voluntary.

The second part ask participant to select from provided list information about the:, gender, age, geographical origin, professional/educational status.

Third part asks participants to select from the list one of emotions they associate with presented to them silhouette video film. The questionnaire contains 78 videos, each 30 sec long. All participants will use the same generic questionnaire.
The resulting data will be returned by email to University of Dundee server when evaluated the results will be kept on secure research server at Gotland University where I have research account.

Brief description of participants and recruitment methods:

The groups participating in the interactive questionnaire will include: community of performance artists, computer science, design/animation, art students and researchers.
All groups will be approached by email, followed by face to face recruiting in public areas of Dundee University

3 Release Form for Individuals

DATE OF FILMING:

PROGRAMME WORKING TITLE:

CLIENT:

SUBJECT'S NAME:

ADDRESS:

LOCATION:

I understand that the videotape taken of me at the above location for ____________________ is the exclusive property of ____________________ . I have been made fully aware of the nature of the proposed programme. I also understand that all copyright in the material belongs exclusively to and/or is hereby granted to ______________ and by signing this form I am granting to ______________ permission for some or all of the pictures and/or recorded sound to be used in connection with the above programme in any media in perpetuity throughout the world.

I also hereby irrevocably waive the benefits of law known as "moral rights" including without limitation any rights under the 1988 Copyright Designs and Patents Act or any similar laws of any jurisdiction.

This material will be used for educational purposes only and not for commercial exploitation.

Signature :___________________________

Name :___________________________

Organisation :___________________________

Date :___________________________

Appendix F

Questionnaire Information

The primary purpose of this questionnaire is to determine if it is possible to identify and label an individually expressed emotion represented as a visual artefact in form of a single silhouette in one frame.

The secondary purpose is to find the symbolic values of colours in relation to emotions, cultural and geographical affinities.

This exercise and the answers in the questionnaire are voluntary and all data will be treated with full confidentiality. The participant can withdraw from the research at any time without penalty and for any reason.

Emotion Exercise
Students from dance, theatre and media departments at different universities and the various countries are asked to perform for a maximum of one minute against white background in front of the web-camera that is supposed to register the whole body movement. The student will register this performance on video film. One frame of the video, which best represents the emotional value of the performance, will be extracted by the student and converted to silhouette, and digitally uploaded to the server together with the questionnaire. Each questionnaire has a unique number that is equal to the uploaded silhouette image. Each student will perform one emotion chosen from a total number of eight.

a) Joy
b) Trust
c) Fear
d) Surprise
e) Sadness
f) Disgust
g) Anger
h) Anticipation

Questionnaire   nr.……………

1. Gender:
2. Age:
3. Country:
4. Background:
   a) Dance / choreography studies
   b) Theatre studies
   c) Media studies

5. Choose one of the emotions you performed and converted to the one-frame silhouette.
   a) Joy
   b) Trust
   c) Fear
   d) Surprise
   e) Sadness
   f) Disgust
   g) Anger
   h) Anticipation

5. From the pallet of 8 colours below select the one that best describes this emotion?
…………………

6. Note a suitable colour number next to each emotion.

a) Joy …………….

b) Trust ……………..

c) Fear ……………..

d) Surprise ……………..

e) Sadness ……………..

f) Disgust ……………..

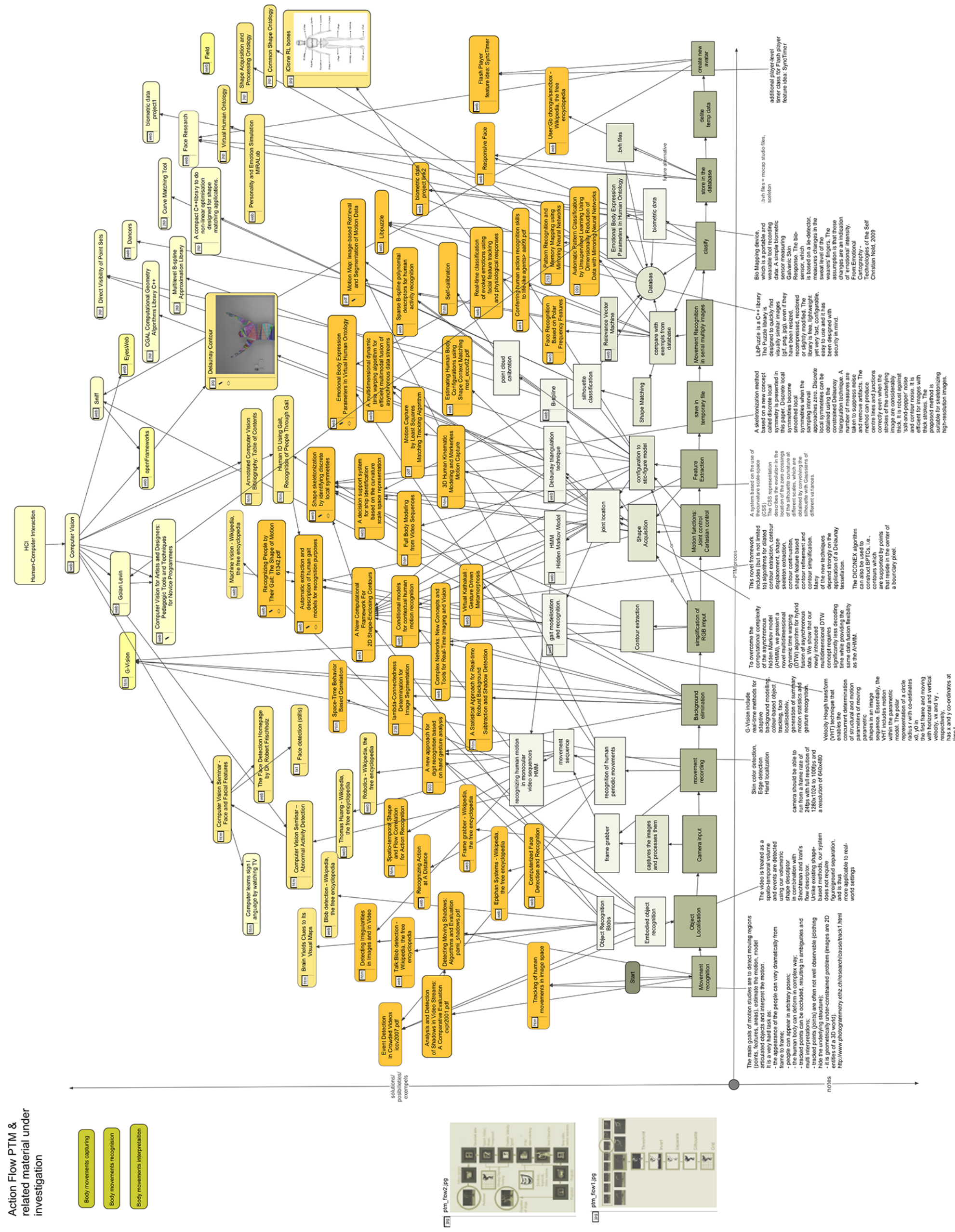
g) Anger ……………..

h) Anticipation ……………..

Thanks for your participation.

Appendix G

Action Flow PTM & Related Material During The Contextual Research


Action Flow PTM & related material under investigation
Body movements capturing
Body movements recognition
Body movements interpretation

Appendix H

1. V Dama Workshop. Tallinn, Estonia, March 22-31, 2010



The Estonian Academy of Arts is hosting the fifth Dama workshop. Through the DAMA network, this workshop is open to the participating institutions. The workshop takes place in Tallinn on March 22-31, and students will work together in groups, leading to a final performance / presentation.

The workshop is intended for students of performance based art (real-time art): music, dance, video, multimedia etc. The goal is to provide a platform for students of different disciplines to work together using their domain-specific skills in a multimedia environment.

See: http://www.medialappi.net/dama
Time: 22.3 – 31.3.2010
Place: Estonian Academy of the Arts, Tallinn, Estonia
Duration: 8+2 days
Participants: max 30 students
Level: Intermediate / Advanced
Working language: English
Recognition: Students should confirm that the course can be accepted into their studies at their home university.

Workshop coordinators (content): Tomi Knuutila tomi.knuutila@ulapland.fi, Lecturer in Digital Media, University of Lapland; Raivo Kelomees offline@online.ee, Professor / Head of Department, Estonian Academy of the Arts

Workshop coordinators (practical issues): Maria Jürisson maria.jurisson@artun.ee, Assistant; Sandra Sule 402esion.sule@artun.ee, Head of International Office
Lecturers: Áki Ásgeirsson, Tomi Knuutila, Iwona Hrynczenko, Karen Maria Jónsdóttir

Goal:
Students get acquainted with the technical possibilities of connecting different media in real-time. Special emphasis will be on the interaction between movement, music and graphics. Students learn to use experimental yet simple-to-use sensor technology for artistic purposes. In addition students learn to work in a multidisciplinary and international team. The student gains knowledge in physical computing and dance technology. The students work together in groups, creating an installation, performance or interactive experience as the final work.

Content and methods:
Students will experiment with sensor technologies in controlling visual, spatial and musical elements. Various computer interfaces and software is introduced as necessary. Workshop leaders will introduce their own work and multimedia / performances by known artists. Relationships of media, technology, movement, space and time are discussed. Small exercises and theory lessons guide the creation of the final work.

Theme: tba

Pre-assessment: Make a short presentation (5-10 minutes) about an artist, performance or artwork that you find inspirational. The presented subject should come from a field outside your main interest or combine many fields if possible. Presentations are shown on Monday 22 March.

Grading: Pass or fail (or according to each institutes' own system) Application procedure
Send mail to Tomi Knuutila and Raivo Kelomees explaining with a motivation letter before February 12.2010.
The motivation letter should contain explanations in the following areas:
• Background knowledge in music, dance, art and / or media.
• Background or interest in cross-disciplinary work.
• Will to work in a collaborative and international group.

Prerequisite:
Intermediate / advanced level in own field of study.
Performing art students: some skills in new media tools and technologies are beneficial. Media / music / fine arts students: Some dance or other performative skills are beneficial.

Timeline:
12.2.2010 application deadline
19.2.2010 information about the selection, travel stipend procedure etc.
19-21.3.2010 Arrival to Tallinn, accommodation etc.

22-30.3.2010 The course itself (weekend is free / working time)
31.3.2010 Final performance
9-10.5.2010 Departure from Tallinn

Accommodation:
Visiting students will stay in a youth hostel. Close to EAA at Kiriku plats 1, Tallinn 10130, where the workshop will take place.
Please bring with you:
• Bed linen or a sleeping bag & towel & personal toiletries
• If possible, a laptop computer and audiovisual equipment (digital camera, video camera, sound recording equipment, sensors, etc.)
• Good ideas
• Ability to work and live in an international group

Costs:
The workshop is free. The students will get a mobility stipend, amount depends on which country the student is coming from. The travel and accommodation are then covered by the students themselves with the money. Participants have to be prepared to pay for meals or cook on their own.

More information:
Workshop coordinators: Áki Ásgeirsson, Karen María Jónsdóttir and Tomi Knuutila.
Links:
Estonian Academy of the Arts on map: Kiriku plats 1, Tallinn 10130
Visit Estonia: Tallinn
Tallinn in your pocket
Tallinn Weather
Addresses:
Iceland Academy of the Arts, Visual Art Department
Kiriku plats 1, Tallinn 10130
Hostel (no info yet which one)
Telephone numbers:
Estonian Academy of Arts, 403esions403nt of New Media: +616 4218
Tomi Knuutila: +358 40 5024115
Raivo Kelomees: +372 616 4218
Sandra Sule: +372 626 7369
Emergency: 112

2. The VI Dama Workshop Reykjavík, Iceland, October 4-9, 2010

Iceland Academy of Arts is hosting the sixth Dama workshop. Through the DAMA network, this workshop is open to the participating institutions. The workshop takes place in Reykjavik on October 4 – 9, 2010, and students will work together in groups, leading to a 6. Dama workshop file:///Users/iwonaH/IIDisk/Documents/DAMA/Dama6/6. D… 1 of 4 1/7/13 2:05 PM final performance / presentation, which will happen during the Ke›ja Reykjavík encounter.

The workshop is intended for students of performance based art (real-time art / time-based art): music, dance, video, multimedia etc. The goal is to provide a platform for students of different disciplines to work together using their domain-specific skills in a multimedia environment. See: http://www.medialappi.net/dama

Time: 4.10 – 9.10.2010
Place: Iceland Academy of the Arts, Reykjavik, Iceland
Duration: 5+1 days
Participants: max 20 students
Level: Intermediate / Advanced
Working language: English

Recognition: Students should confirm that the course can be accepted into their studies at their home university.

Workshop coordinators (content): Tomi Knuutila tomi.knuutila [at] ulapland.fi, Lecturer in Digital Media, University of Lapland; Karen-María Jónsdottir karenmaria [at] lhi.is, Program Director of Contemporary Dance, Iceland Academy of the Arts
Lecturers (tbc): Áki Ásgeirsson, Tomi Knuutila, David Yoken(?), Iwona Hrynczenko, Karen Maria Jónsdóttir, Kai Valtna

Goal:
Students become acquainted with the technical possibilities of connecting different media in
real-time. Special emphasis will be on the interaction between movement, computer media and interaction. Students learn to use experimental yet simple-to-use sensor technology for artistic purposes. In addition students learn to work in a multidisciplinary and international team. The student gains knowledge in spatial installation, physical
computing and dance technology. The students work together in groups, creating an installation, performance or interactive experience as the final work.

Content and methods:
Students will experiment with sensor technologies in controlling visual, spatial and musical elements. Various computer interfaces and software is introduced as necessary. Workshop leaders will introduce their own work and multimedia / performances by known artists. Relationships of media, technology, movement, space and time are discussed. Small exercises and theory lessons guide the creation of the final work. Morning / warming exercises will help everyone get started.

Theme: tba

Pre-assessment: One minute of fame. You have exactly one minute to present yourself. It can be in the form of a speech, performance, video, interactive presentation, etc. Presentations are shown on Monday 4 October.

Grading: 1-5 or fail (or according to each institutes' own system)

Application procedure
Send a motivation letter by email to Tomi Knuutila and Karen-Maria Jónsdóttir. Due

September 15, 2010.
The motivation letter should contain explanations in the following areas:
Background knowledge in music, dance, art and / or media.
Background or interest in cross-disciplinary work.
Will to work in a collaborative and international group.

Prerequisite:
Intermediate / advanced level in own field of study.
Performing art students: some skills in new media tools and technologies are beneficial.
Media / music / fine arts students: Some dance or other performative skills are beneficial.

Timeline:
15.9.2010 application deadline
19.9.2010 information about the selection, travel stipend procedure etc.

1-3.10.2010 Arrival to Reykjavík, accommodation etc.
4-8.10.2010 The course itself
9.10.2010 Final performance – 12:00 at the dance and theatre academy. “Adventures in the academia”, part of the Ke›ja Reykjavík encounter.
10 – 12.10.2010 Departure from Reykjavík

Accommodation:
Visiting students will book their accommodation themselves.
Please bring with you:
Bed linen or a sleeping bag & towel & personal toiletries
If possible, a laptop computer and audiovisual equipment (digital camera, video camera, sound recording equipment, sensors, etc.) Good ideas. Ability to work and live in an international group

Costs:
The workshop is free. The students receive a mobility stipend, an amount depending on which country the student is coming from. The travel and accommodation are then covered by the students themselves with the money. Participants have to be prepared to pay for meals or cook on their own.

More information:
Workshop coordinators: Aki Asgeirsson, Karen María Jónsdóttir and Tomi Knuutila.
Links:
Iceland Academy of the Arts, Dance and Theatre department, Sölvhólsgötu 13 on map:
12.2 Dama workshop file:///Users/iwonaH/IIDisk/Documents/DAMA/Dama6/6. D…
3 of 4 1/7/13 2:05 PM
©2012 Google -
Map data ©2012 Google –
View Larger Map
Inspired by Iceland
Visit Reykjavík
Iceland Weather and Earthquake(!) info
Addresses:
Iceland Academy of the Arts, Department of Theatre and Dance:
Sölvhólsgötu 13

Telephone numbers:
Iceland Academy of Arts, department of Dance: +354 552 5020
Iceland Academy of Arts, department of Fine arts:+354 520 2400 (in case of equipment borowwing etc.)
Tomi Knuutila: +358 40 5024115
Karen Maria Jónsdóttir: +354 6996903
Áki Ásgeirsson: +354 6619731
Emergency: 112

3. VII Dama Workshop. Visby, Sweden, June 6-15, 2010

Photo from previous DAMA workshps: △ DAMA1 Reykjavik ▽ DAMA5 Tallinn

Gotland University is hosting the seventh Dama workshop. Through the DAMA network, this workshop is open to the participating institutions. The workshop takes place in Visby on June 06-15, and students will work together in groups, leading to a final performance/presentation. The workshop is intended for students of performance based art (real-time art): music, dance, video, multimedia and games. The goal is to provide a platform for students of different disciplines to work together using their domain-specific skills in a multimedia environment. See: http://www.medialappi.net/dama

Physical Gaming, Performing space and Media
12.3 escts

Time: 06.6.2011-15.6.2011
Place: Visby. Gotland. Sweden.
Gotland University. Institution of Game Design, Technology and Learning. Game

Department
Duration: 10 days
Level: Intermediate/advanced
Working language: English

Recognition: Students should confirm that the course can be accepted into their studies at their home university.

Workshop coordinators (content): Tomi Knuutila tomi.knuutila@ulapland.fi, Lecturer in Digital Media, University of Lapland; Iwona Hrynczenko, iwona.hrynczenko@hgo.se Lecturer in Interpretation towards Digital Design, Institution of Game Design, Technology and Learning, Gotland University; Steven Bachelder, Professor, Institution of Game Design, Technology and Learning, Gotland University

Workshop coordinators (practical issues): Iwona Hrynczenko iwona.hrynczenko@hgo.se; workshop coordinator on Gotland
Suk-hi Cho, suk-hi.cho@hgo.se Head of International Office
Leading Tutors: Tomi Knuutila, Karen Maria Jónsdóttir, Iwona Hrynczenko, Albertina Sparrhult

Course description
Course goal:
The 10 days intensive Course provides students with knowledge about the common ground shared by dance, games and media, and encourages learning more about other students' disciplines. The students work together in groups, creating an game based performance or interactive experience as the final work.

Content and methods:
The course will focus on the space between dance/theatre and games: where games become art and dance/theatre becomes interactive. Techniques from the dance/theatre will be used to design new games and interactive (game) techniques will be used to make dance/theatre. The student will research and develop a crossover between games and performance. She/he will learn to deal with different software hardware and theatrical techniques. She/he will learn to work in a team or as a collective on artistic and innovative concepts and how to adapt them to an artistic context. The development of and experimenting with innovative concepts of virtual theatre and games is a central issue here. Dance students will benefit by both using theatre techniques as well as game development theories for choreography exercises. It will extend the issue of connectivity between movement and content in the choreographic dance work.

Application procedure
Send e-mail to Tomi Knuutila and Iwona Hrynczenko explaining with a motivation letter before April 25.2011
The motivation letter should contain explanations in the following areas:
• Background knowledge in music, dance, art and/or game development/media.
• Background or interest in cross-disciplinary work.
• Will to work in a collaborative and international group.

Preliminary Course schedule:
Pre-assessment:

Make a short presentation (5-10 minutes) about an artist, performance or artwork that you find inspirational. The presented subject should come from a field outside your main interest or combine many fields if possible. Presentations are shown on Monday 06 June.

Preliminary workshop schedule:
Research and preparation between collaborating experts performing art/dance and Media / game development. Workshops are based on teamwork where participants explore core techniques and existing media tools. The preliminary workshop program will be based on 4 phases:

Day 1-2
First Phase: Knowledge exchange/inspiration phase. The students present examples of works that influence themselves, as well as a specific technique, which is connected to this work. They can present it for other students as a short practical workshop. Teachers will also give an introductory presentation of the specific subject and case-based examples.
Introduction to Game Development: For both creative and vocational issues, introductory lectures to the theory and practice, and then application to the specific game activities.

Day 3
Second Phase: team building and idea development where students together formulate their ideas.

Day 4-8
Third phase: idea realization based on already existing media tools and performative techniques.

Day 9-10
Fourth phase: presentation. The two weeks of theory preparation should be carried out in the practical work during the workshop.

Post-assessment:
Written project synopsis, and project documentation, (Group work) supplemented by your own reflections in the form of written analysis of your collaboration experience.
Last day to deliverer: 30 June 2011. To Both Tomi Knuutila tomi.knuutila@ulapland.fi and Iwona Hrynczenko iwona.hrynczenko@hgo.se

Teaching methods:
Phase 1: Case studies, learning by teaching, demonstrations, panel of experts, lecture with discussion (teachers).
Phase 2: Brainstorming, small group discussion, collaboration (students), couching (by teachers).
Phase 3: Project based education, problem-based learning.
Phase 4: Participatory techniques, group-work, problem solving, learning to make positive compromises.

Outcomes: Short production based on elements/techniques representing knowledge of each participating student group. Key People & departments involved: From Gotland University Game department: Teacher for the introduction to game development, *Mocap capture studio* technician, teacher in digital media visualization.

Grading: Pass or fail (or according to each institutes' own system)
Application procedure: each institution does the selection beforehand.
Prerequisite:
Intermediate / advanced level in own field of study.
Performing art students: some skills in new media tools and technologies are beneficial. Media /music / fine arts students: Some dance or other performative skills are beneficial.

Timeline:
18.4.2011 application deadline
25.4.2011 information about the selection, travel stipend procedure etc.
05-06.6.2011 Arrival to Visby, accommodation etc.
06-15.6.2011 The course itself (weekend is free / working time)
15.6.2011 Final performance
15-16.6.2011 Departure from Visby

Accommodation:
Visiting students will stay in a youth hostel. Please bring with you:
• Bed linen or a sleeping bag & towel & personal toiletries
• If possible, a laptop computer and audiovisual equipment (digital camera, video camera, sound recording equipment, sensors, etc.)
• Good ideas
• Ability to work and live in an international group
Hostel
We have made reservations at Hostel Visbyfängelse.
Location: 200 m from the ferry terminal, just inside of the Visby old walls. 200 m to beach, 200 m up to the centre of old Visby
Website: http://www.visbyfangelse.se
Telephone: +46 498-206050 booking +46 18 106905
More info about the hostel:
http://www.hostelz.com/hostel/41852-Visby-Prison-Hostel---Visby-Fängelse-Vandrarhem
Important:
For booking first you need to send an e-mail to Iwona before the 1 of May.
Iwona.hrynczenko@hgo.se
Your e-mail address and name will be sent to the hostel in order to connect you to this reservation. You need to confirm the booking yourself and make necessary payments before 6 of May by telephone or website using DAMA as reference. (your name + DAMA). Price: 25 EUR/night.

Costs:
The workshop is free. The students will get a mobility stipend; amount depends on which country the student is coming from. The students themselves with the money then cover the travel and accommodation. Participants have to be prepared to pay for meals or cook on their own.
More information:
Workshop coordinators: Tomi Knuutila , Iwona Hrynczenko, Karen María Jónsdóttir and. Albertina Sparrhult

Links:

Gotland University: http://www.hgo.se
Gotland University, Game Department: http://game.hgo.se
Your guide to Gotland: http://www.gotland.info/language/eng
Addresses:
Gotland University, Game Department
Cramérgatan 3, 621 67 Visby
Hostel: Visby
Fängelse
Vandrarhem,
Skeppsbron,
1621
57
Visby
Telephone numbers:
Tfn: +46 (0)498 29 99 00, Game department
Tomi Knuutila: +358 40 5024115
Iwona Hrynczenko: +46 704546748
Albertina Sparrhult: +46 762184891
Emergency: 112

Appendix I

Flowchart of Human Movement Classes

Human corporeal movement classes
in relation to the Phenomenological inquiry

Human corporal movement classes in relation to the Phenomenological inquiry

Question:
Is it possible to translate emotional style of corporal robust body movement in to the digital environment by defining movement's classes and properties?

Idea development /methods
1. Define classes of movement.

2. Apply Plutchik's Theory to the idea of Expressive Gesture.
3. Find suitable dance notation or combinations for registration of movement's patterns.

4. Define properties of robust body movement.

5. Make emotion representation models using MM (Mapping Motion tool).
6. Check the reliability of visual models against human perception of emotion.

Infant-adult development (Brains development)

Corporeality Live Body	Relationality Lived Human Relation	Temporality Lived Time	Spatiality Live Space	Explanations
Contemplative Movement	Self referential*	Often repetitive and short, or single and slow	Begins from body centre, based on balance, whole body From small to huge volume capacity	Movements which purpose is to change performers state of mind. Sometimes to provoke sensation and spiritual harmony.
Lingua-Supportive Movement	Self referential but only used in relation to other humans	Repetitive and short yet dependent on time in verbal sentences Regular loops	Starts symmetrically from joints in the upperbody Small to middle volume capacity	Movements supporting a verbal communication, spontaneously generated by a person telling a story, speaking in public, or holding a conversation.
Communicative Movement	In relation to others (humans or animals)	Short and single often serial	Irregular From small to huge volume capacity	Movements that consist symbolical sings instead of words.Oldest form of language and that it evolved before or perhaps simultaneously with speech. Example; a greeting.
Habitual Movement	In relation to objects, humans or animals	Often short and repetitive often serial	Irregular From small to huge volume capacity	Movement to move another human, animal or an object (example may be use of tools during activities as eating, drinking, working).
Generic Movement	In relation to existential needs	Irregular depends on mission	Irregular From small to huge volume capacity	Movements that are an reaction on circumstances could be conscious or unconscious mainly supporting existential needs on a basic level like: reach out, walk, self-protect, movements, which we train from the very first days of our existence helping with surviving.
Reactive Movement	I in relation to existential circumstances, or provoked by another human, animal, or object	Irregular depends on case and person	Irregular From small to huge volume capacity	Movements that express a mood or feeling provoked by the state of the mind, which consequently can occur in relation to existential circumstances, or provoked by another human, animal, or object.

Appendix J

Statistic Data Samples for Plutchik's Colour Comparison

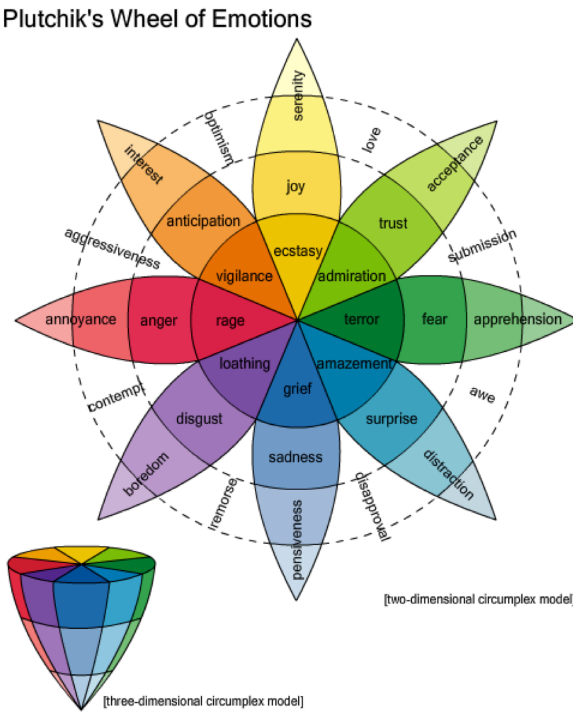


Figure 1. Plutchik's Colour Wheel.

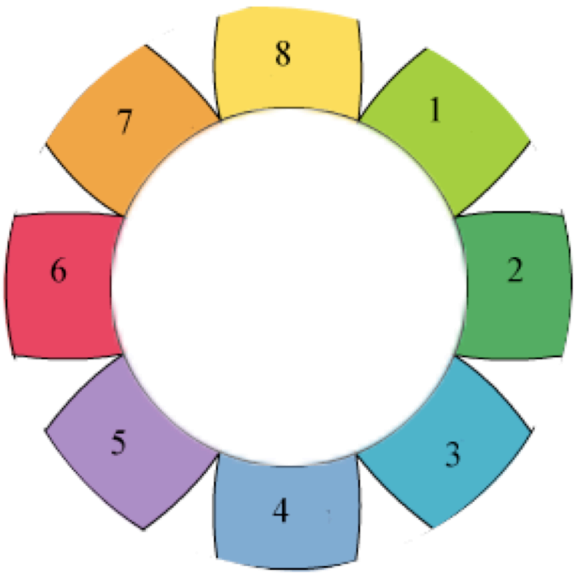


Figure 2. For comparison chosen colours.

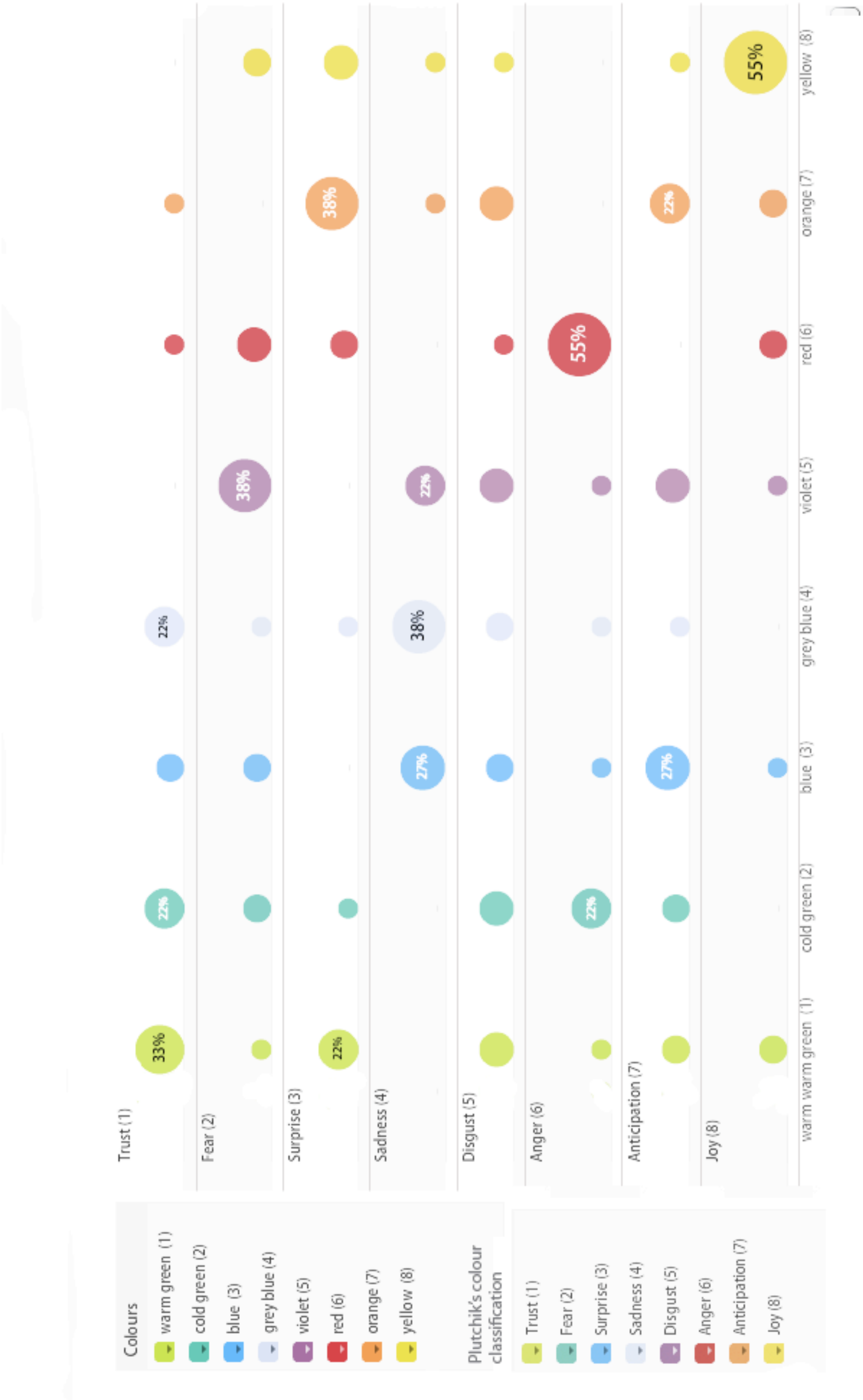
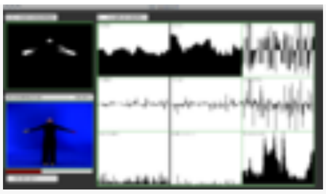

Trust (1)
Fear (2)
Surprise (3)
Sadness (4)
Disgust (5)
Anger (6)
Anticipation (7)
Joy (8)
warm warm green (1)
cold green (2)
blue (3)
grey blue (4)
violet (5)
red (6)
orange (7)
yellow (8)
33%
22%
22%
38%
22%
38%
27%
22%
38%
22%
55%
27%
22%
55%
Colours
warm green (1)
cold green (2)
blue (3)
grey blue (4)
violet (5)
red (6)
orange (7)
yellow (8)
Plutchik's colour classification
Trust (1)
Fear (2)
Surprise (3)
Sadness (4)
Disgust (5)
Anger (6)
Anticipation (7)
Joy (8)

Figure J0.1

Appendix K

VideoAnalysis Software

VideoAnalysis main window



Preview window

Features

Imports a folder of video files for batch processing

Realtime previewing of video, motion image, motiongrams and analysis of data that outputs horizontal and vertical motiongrams.

The output files are saved in the location of, and names based on, the original video file.

Outputs a text file with the following data:

The first column contains a time stamp.

Columns 2 through 10 contains filtered data

Columns 11 through 19 contains unfiltered data:
Xposition, Yposition, Xvelocity, Yvelocity, absolute velocity, direction, absolute acceleration, change in direction, Quantity of Motion

The data generated by VideoAnalysis

The data is exported to textfiles, named after the video files. The text files have 19 columns, where the first column displays time, the contents of the next 9 columns are data with an applied medianfilter, and the last nine columns are unfiltered data.

Column 1: **Time stamp**

This is currently not measuring correct units, please disregard the time-stamp until it has been implemented correctly. Each row in the text file contains data for a single video frame, thus for now sample index is a better time-measure.
Column 2: **X position**

The horizontal position of the center of gravity. X = 0 means that the center of gravity is located to the left in the picture
Column 3: **Y position**

The vertical position of the center of gravity. Y = 0 means that the center of gravity is

located in the bottom of the picture
Column 4: **X velocity**

The first derivative of X position. The difference between the X[n] and X[n-1], where X is the X position (in pixels) and n is the sample index. X velocity > 0 means that the center of gravity moves to the right.
Column 5: **Y velocity**

The first derivative of Y position. The difference between the Y[n] and Y[n-1], where Y is the Y position (in pixels) and n is the sample index. Y velocity > 0 means that the center of gravity moves upwards.
Column 6: **Absolute velocity**

The first derivative of position. The distance component of the polar representation of X and Y velocities. Absolute velocity = √(Xvelocity^2 + Yvelocity^2).
Column 7: **Direction**

This is the direction of the movement of the center of gravity from the previous frame to current frame.
Direction = 0 means a movement to the right
Direction = pi/2 means an upwards movement
Direction = -pi og pi means a movement to the left
Direction = -pi/2 means a downwards movement
Column 8: **Absolute acceleration**

The second derivative of position, i.e. first derivative of absolute velocity. The difference between V[n] and V[n-1] where V is absolute velocity, and n is the sample index. This implies that if the absolute acceleration is 0, then the absolute velocity is equal in two succeding frames. If absolute acceleration is greater than 0, the speed increases.
Column 9: **Change in direction**

This value is meant to show the angular velocity of the center of gravity. This is not properly implemented yet, as there is no compensation for the flipping between direction = pi and direction = -pi.
Column 10: **Quantity of motion (QoM)**

A normalized value for the total movement in the current frame. QoM = 1 means that all the pixels in the video change from one picture to another, QoM = 0 means that there is no movement in the picture since the previous frame.
Columns 11 through 19 are the unfiltered equivalents of columns 2 through 10.

Information retrieved from:

http://fourms.wiki.ifi.uio.no/Quantitative_video_analysis

Appendix L

Network Diagram (yEd,) in Colour, Correlations Among Postures and Emotions.

Appendix M

Periodic Table of Movements Graph

Appendix N

Academic Publications and Conferences

This section presents conference presentations and screenings during different periods of the doctoral study.

Shadow dance: installation and discussion on proposed solutions for embodied games through cross-disciplinary workshops within an educational context.
DRHA 2010 Digital Resources for the Humanities and Arts. Brunel University, London / THEME: Sensual Technologies: Collaborative Practices of Interdisciplinarity
Research paper presentation and screenings (Appendix 8).

Catch me if you can. Motion Capture Methodologies workshop. 2010 University of Sussex in Brighton. AHESSC (Arts & Humanities e-Science Support Centre) and JISC, in collaboration with the Motion in Place Platform Project.
Invited speaker, research presentation.

International symposium "As Yet Impossible: in human performance" at Media City, in Manchester 2011 organised by University of Salford
Invited delegate in participatory workshops and discussions.

Symposium; The Future of Game Design, The International Research School of Game Design (IRSGD) Sweden. 2010.
Invited speaker, research presentation.

The Industry of Forgetting refers to the context of documentation strategies in memory politics, body practice and experience, and autobiographical truth-making.
Collaborative shift at the *Psi #18 Conference* at the University of Leeds. 2012.
Collaborative investigation presented by other members of the group: Maria Hetzer, University of Warwick (UK)/Cara Berger, University of Glasgow (UK)/Awelani Moyo, University of Warwick (UK)/Maiada Salfiti, Sheffield Hallam University (UK).

One Workshop, Two Urban Games: Case Report on Education Models at the Intersection of Dance/Performance Art, Media Art and Game Design, in collaboration with DAMA collaborative published paper with Tomi Knuutila, University of Lapland (FI) The Journal of the Society for Art and Science and presented at NICOGRAPH International Conference 2014, Visby, Sweden.

Appendix O

PTM Database Information

The documentation of the online published database is provided in attached to this thesis DVD, (DVD/ Video 4). The database is presented online on a temporary server and available at: http://www.emdb.pindelski.info

Login system is based on two steps: standard login and private login that need to be always accomplished.

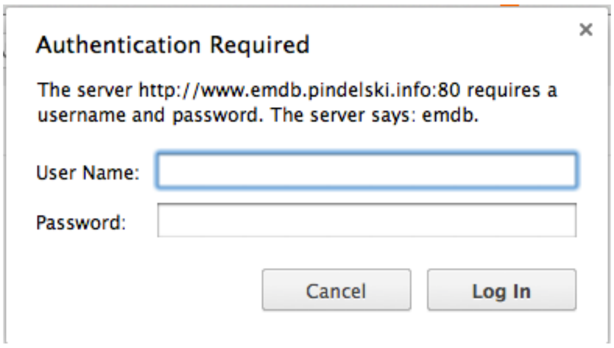


Figure 1.

During the standard login (figure 1) the user will need to type first the standard login and password according to information below.

Login: emdb,
pasword: emdb1234

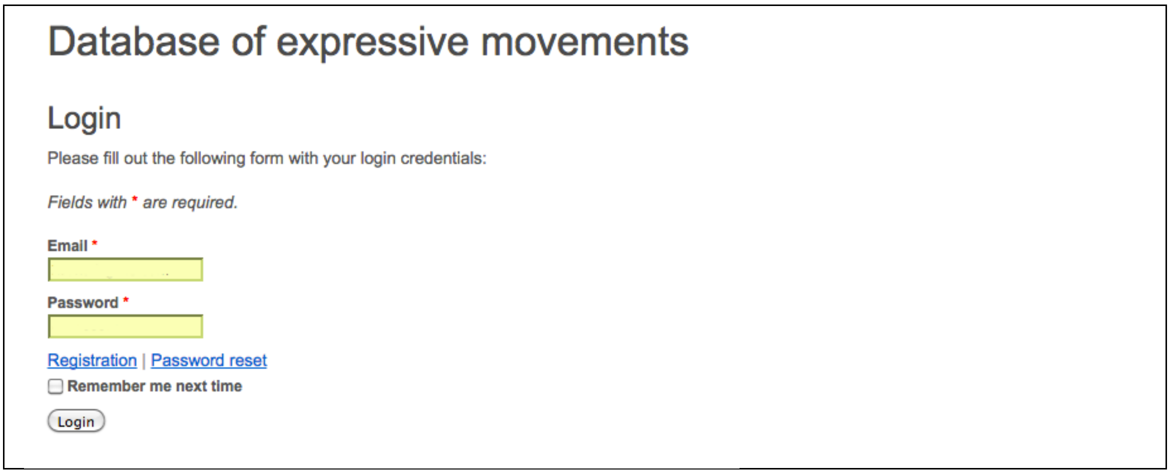


Figure 2

In the next step the new window for private login will appear (figure 2) In this second step the new user need to first click on "Registration" link in order to fill out the form with a private login credentials (figure 3). These credentials will be necessary for private login in the previous window (figure 2).

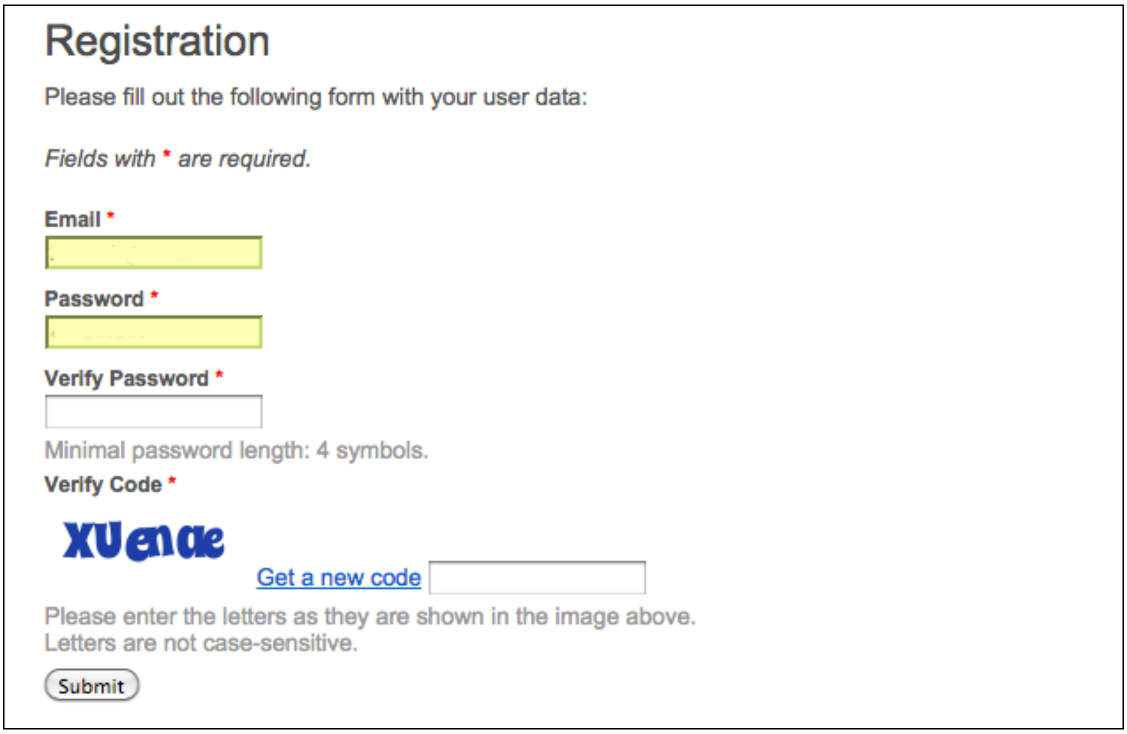

Registration
Please fill out the following form with your user data:
Fields with * are required.
Email *
Password *
Verify Password *
Minimal password length: 4 symbols.
Verify Code *
Get a new code
Please enter the letters as they are shown in the image above.
Letters are not case-sensitive.
Submit

Figure 3

Appendix P

Workshops

> *Tell me, and I will forget. Show me, and I may remember. Involve me, and I will understand (Confucius circa 450 BC).*

This chapter describes the DAMA workshops in the context of the DAMA network, the previously described pedagogical tools, the relevance to my research and my pedagogical involvement as a tutor and organiser. At the same time via documentation of workshop outputs, such as students' work, I argue for the use of a cross-disciplinary environment in educational contexts where physical exercises have a place, especially in the curriculum of digital media/ interface design/games design courses.

1 DAMA Workshops Background

Emergent technologies have opened possibilities for physical expressions in the digital domains. Although during the growth of new digital cultures, human-computer interaction was mostly technology driven, the disembodiment became obvious, since interaction with computers is still limited primarily to hand movement. In this scenario, it become obvious that it exists a need to dissolve boundaries among cognitive sciences and the somatics and aesthetics (Bhat. 2013), in which the best place to start is on educational level. As a result, the platforms for knowledge exchange across faculties of Art, Performance Art, Media Art, and Computer science became a starting point for the DAMA network via cross-disciplinary courses in the form of co-organised workshops. The interdisciplinary network project was created in 2005, encompassing students and teachers from Computer Science/Media Art and Dance/Performance Art. The Nordplus -funded Dance and Media Art Network (DAMA) encloses universities within the European Nordic and Baltic regions.
From 2005, the network expanded from five to twelve participating higher education institutions, witnessing the growing demand for cross-disciplinary platforms required to meet a "new logic in the non-linear sense" (Munster, 2006, p. 26). The outputs of the workshops have provided a new embodied interaction model based on the working learning processes.

2 DAMA Workshops Aims

The DAMA workshops comprise several correlated aims, described as follows;

- To build creative preconditions for the two cultures; performance art and digital media (dance and theatre + emerging technology) in a creative environment.
- To provide workshops where students can practice cross-cultural and cross-disciplinary communication and domain-specific skills in a multimedia environment.
- To provide conditions for teamwork where participants learn how to work in a group, how to make positive compromises and work in multicultural and international environment. DAMA Workshops Methods

The methods applied during the workshops used a phenomenological approach (Van Manen, 1990) founded on practice-based creative experimentation, interpretation and reflection. The workshops are practice based and project-orientated, and build on an iterative series of learning loops, where students in small teams develop ideas and present the final project during the last days of the workshop. The role of the participating teachers is to design the workshop curriculum, provide the knowledge base, organise practice-based exercises, and guide the students individually during the idea development and realisation process. Participating teachers assess and give the feedback on the final project.

At the beginning of each workshop, relevant theoretical background from each discipline is introduced followed by a description of the workshop development, directing attention to the challenges posed by cross-disciplinary environments. The workshops are usually eight to twelve days in duration wherein the first two days of work serve as an inspirational and theory knowledge package. During the first day of the workshop, students individually present and discuss the work of the artist that inspires them most. On the second day tutors introduce their own research as well as the sources of their own inspiration and discuss the issues of their professional interest. During both introductory days the relationships between media, technology, movement, space and time are discussed, followed by practical exercises and theory lessons. These preparations are aimed at guiding the students in the creation of the final teamwork project. Usually the third day is used for small practical exercises and team building, and the fourth day is devoted to idea development by the teams. During the remaining time of the workshop, the students develop the projects in teams, culminating in the final project presentation during the last two days of the workshop.

The workshop curriculum is focused on the teamwork process. All projects that are developed during the workshops are derived from and are grounded in teamwork. Each team forms their own idea around the proposed theme creating their own narrative entity building on culture, attitudes, knowledge and even fears. Working in a cross-disciplinary team, PTM demands from the students a new working manner and attitude, which sometimes puts pressure on team members in terms of flexibility and willingness to compromise. Therefore, the role of tutors is important, especially when participating in the group discussions, in order to provide a perspective that relates to proposed aims of the artwork and to provide students with tools for negotiation. This part is substantial for the goals of DAMA workshops and is perhaps more important than the final artworks.

3 Workshop Connection to PTM Research

The workshops that are connected to this research took place in three different locations and occasions; Tallinn, Estonia in March 2010; Reykjavik, Iceland in October 2010; and Visby, Sweden in June 2011, all of which depended on the DAMA network curriculum. Each of the workshops was practice-based and had a thematic curriculum developed collectively by participating teachers. The preparations for the workshop usually began as an online discussion among participating teachers three months before the workshop and the framework was developed according to the teachers' backgrounds and their own field of knowledge. I presented in January 2010 the subject of my doctoral research to the participating teachers, which they found relevant to integrate into the curriculum. The Pedagogical toolset described in section 4.2 *Pedagogical Toolset* was introduced during the following workshops and I was allocated time and space for expressive movement documentation. The entire curriculum for all workshops can be seen in Appendix H.

During the following three workshops, participating teachers and students became my partners in the discussions on tools and idea development. In the following three sectionss, the workshops are described in the context of my involvement, the use of the pedagogical toolset, and partly how these are reflected in the students' work. The expressive movement documentation process is described in the section 4.3 *Emotions/Movement documentation process* connecting all three sections with each other.

During the workshops, dance, media art, computer science and game students participated and the aim of the toolset was to introduce movement-based knowledge in an intuitive and visual way to the students for whom the concept of body and movement seemed foreign as an interface. Equally focused was the aim of the workshops to introduce movement based devices for students who did not feel confident with digital technology.

3.1 The 5th DAMA Workshop, Tallinn

The 5th DAMA workshop was hosted by Estonian Academy of Arts, Department of New Media and took place in Tallinn, Estonia on March 22-31, 2010
The focus of the workshop was on the interaction between the camera, movement, music and graphics along with the experimental and simple-to-use sensor technology. The participating students, 10 from media and 11 from dance/ performance departments came from:
Danish National School of Theatre and Contemporary Dance (Denmark)
Estonian Academy of Arts (Estonia)
Iceland Academy of the Arts (Iceland)
Tartu University (Estonia)
Turku University of Applied Sciences (Finland)
University of Lapland (Finland)
As well as myself, the participating teachers were: Tomi Knuutila, lecturer in Digital Media, University of Lapland and Áki Ásgeirsson lecturer in Digital Media and Sound at Iceland Academy of Arts. My teaching colleagues provided technical knowledge and support in terms of technical solutions for input devices as well as in visual art, sound and graphics. The Head of Department of the Estonian Academy of the Arts provided a lecture on art theory.
The Framework of Action Points, as a part of the pedagogical toolset, was applied with some variation during all workshops according to the list below.

1) Physical exercises, such as movement sequences: goal-directed functional, expressive-emotional, parallel mirroring, abstract improvisations, rhythmical introvert, rhythmical extrovert, and communicative gestures in pairs.
2) Group trust exercises such as caring and touching, falling, and catching.
3) Simple character-.based live games using floor and urban space.
4) Dance with cameras (see body movement through the camera in real-time).
5) Camera as a first person shooter (see the space through the camera in real-time.
6) Game development theory.
7) Movement sensors.

Five groups of mixed media dance students produced performances converging different types of media with movement/dance. It is important to point out that the knowledge exchange among students and teachers had a large influence on the output of all workshops. The workshop strategy builds on different elements that supported this approach. Every day began with physical exercises based on dance performance techniques, where all students and teachers participated. Project-based work such as content development and the technical solutions for different media was then carried out. During the workshop, teachers supervised students during the development process, as well as providing lectures in their own specific knowledge area. The final performances were presented by the students at the Estonian Academy of Arts showing a variety of possible adaptations of media/performance art in a cross disciplinary cooperation.

My contribution to the workshop was to introduce to the students the idea of movement as different series of experiences both as a movement of the body but also as movement of the camera/web camera. In the context of this lecture students were given an assignment:

> .. to find a public space and create a movement-based performance in the place, documenting or recording their performance, involving the documentation in the performance (DAMA documentation via Knuutila, 2010).

In this context, the presented and discussed issues were site-specific games, which involved the use of urban space as a basis for the performative ideas. In addition, we have collectively discussed and explored movements based on heuristic guides, *movement classes* (Appendix I), a study described in section 4.2.2 *Flowchart of Human Movement Classes* as a part of the educational toolset. The concept of *inside* and *outside* of the body was explored as well as Gurdjieff's techniques such as movement repetitions based on geometrical forms.

During the workshop, video material of expressive movement as silhouettes was collected. The 16 Frames tool was used as an analytical tool for dance choreography where dancers used silhouettes as a visual expression of movement.
In connection to my investigation on how we perceive colours in relation to emotions across geographic and cultural borders, the students were provided a questionnaire that investigates the relationship between colours and emotions in Plutchik's colour wheel. This in turn created new ideas and discussions on colour theory and human expressions contributing to new exercises. Consequently, one of the discussions led to the

investigation of the phenomenon of synaesthesia. Synaesthesia is a circumstance in which the real information collected by one sense results in a sensation or perception of another. For example, colours can be perceived to have taste or smell and sounds can be perceived to have colours. Therefore, one of the exercises was stimulated by the question: How do you embody or dance red, green, yellow, or blue? (figure P.0.1). In the context of PTM research, the exercises provided connection to colour perception in terms of kinaesthetic and aesthetics of movement. In terms of development of the PTM database, valuable experience was gained for future designs of movement based colour feedback driven by a movement-sensing device such as Microsoft Kinect.


Figure P.0.1 Exercise; Movement as colour. DAMA workshop Tallinn, Hrynczenko, 2010.


Figure P.0.2 Exercises in the city space, DAMA workshop Tallinn, Hrynczenko, 2010

Figure P.0.2 shows exercises in the city landscape where the main objective was to adapt existing features of the city to performance space, in this case, a traffic roundabout.

Figure P.0.3 Movement/body exercises, DAMA workshop Tallinn, Hrynczenko, 2010.

The short exercises in figure P.03 illustrate the movement based pedagogical toolset applied in practice. Figure P.0.4 refers to exercises in a city space and dance with cameras aiming to explore the body movement through the camera where the camera becomes an active subject of the real-time performance.

Figure P.0.4 Movement/body exercises, DAMA workshop Tallinn, Hrynczenko, 2010.

The students' final projects, presented by four groups, illustrate explored issues such as movement with the camera as well as camera as a *first person shooter* (figure P.05).

Figure P.0.5 Industrial Grey-scale, Students work, DAMA workshop Tallinn, Hrynczenko, 2010,

Figure P.06 documents a student project that investigated silhouettes as part of the narrative tool together with simple visualisations using old-fashioned overheads in a *VJ show*. *Game theory*, together with gender issues, is explored in the student project *Russian roulette*, illustrated in figure P.07.

Figure P.0.6 Fairy tale, Students’ work, DAMA workshop Tallinn, Hrynczenko, 2010.

Figure P.0.7 Russian roulette, Students’ work, DAMA workshop Tallinn, Hrynczenko, 2010.

Figure P.0.8 Sushi makes me happy, Students' work, DAMA workshop Tallinn, Hrynczenko, 2010.

The students' project *Sushi makes me happy* explores movement, sound, sensory input and graphics (figure P.08 and DVD/Video 5).

During the Tallinn workshop, the main goal for students was to incorporate dance/performance techniques with visual media and/or with space. Several exercises were used in the urban space as physical interpretations of Tallinn's city as site-specific actions. The characteristic for the workshop was the use of alternative performance locations: corridors, studio rooms, classrooms, basements, attics and the streets of Tallinn. The final performances were partly an exploration of media/body interpretations of different rooms, which students chose themselves using Tallinn's Art Academy building, and partly an inquiry utilising the simple concept of the game in relation to participatory theatre.

3.2 The 6th DAMA Workshop, Reykjavík

The 6th DAMA Workshop, hosted by the Iceland Academy of Arts in Reykjavík, Iceland, during October 4-9, 2010, proceeded on the same terms as the previous workshop in Tallinn. However, the emphasis in this workshop was on participatory performance and games. The Keðja Reykjavik, the International Performing Arts Encounter was also open to participants of the Keðja conference.

The participating students, eight from media/computer science and nine from dance/performance art came from:

Estonian Academy of Arts (Estonia)

Iceland Academy of the Arts (Iceland)

Riga Teacher Training and Educational Management Academy (Latvia)

Tartu University (Estonia)

Turku University of applied sciences (Finland)

University of Lapland (Finland)

The participating teachers besides myself were: Tomi Knuutila, lecturer in Digital Media, University of Lapland; Áki Ásgeirsson, lecturer in Digital Media and Sound at Iceland Academy of Arts; Karen Maria Jónsdóttir, Program Director of Contemporary Dance at Iceland Academy of the Arts; and Kai Valtna, Viljandi Culture Academy of the Performing Arts Department. The participating teachers came from both performance and media art.

Framework of action points:

1) Physical exercises, such as movement sequences: goal-directed functional, expressive-emotional, parallel mirroring, abstract improvisations, rhythmical introvert, rhythmical extrovert, and communicative gestures in pairs.
2) Group trust exercises such as caring and touching, foaling, and catching.
3) Simple character-based live games using floor and urban space.
4) Game development theory.
5) Movement sensors.

During the theoretical part of the workshop, I had an opportunity to introduce to the participating students ideas and theories of participatory theatre based on the ideas of children's play rituals used as exercise in physical theatre. In the workshops practical part, children's and physical games were undertaken by the students (figure P.09).

Figure P.0.9 Children's games exercises, DAMA workshop Reykjavík, Hrynczenko, 2010.

Participatory theatre in its simplest form could be described as activity in which the spectators physically and emotionally are embodied in a theatre experience and its creation. This form of theatre originates from folk traditions, yet during the workshops it was exemplified by children's games where play was mixed with the rules of game that focused on body, time, space and social interaction, This is a form of pre-ritual, whose aesthetics could be described as: repetition, rhythm, tension, variation, recurring patterns, solution, rise and fall. In the context of the workshop, these plays/exercises intend to disconnect the participants from their daily lives sphere. In other words, to create a 'pre-liminal stage', a phase that marks the break ending the old order and a stage before the group come to terms with the new phase, i.e. it is a good way to start the day during the workshop.

The relationship of colours to emotions, based on the results collected during the previous DAMA workshop in Tallinn, was collectively discussed and some of the ideas were implemented in the students' projects. In one of student projects, the audience's colour preferences were investigated as part of the participatory performance based on the question: Whom will the audience choose to interact with first—the red, the blue, the green, or the yellow actor? At the end of the day, the red and yellow actors accounted for most interactions with the participating visitors.

Figure P.0.10 Participatory games, Colour tag, DAMA workshop Reykjavík, Hrynczenko 2010

Figure P.0.11 Participatory games; Children's riddle, DAMA workshop Reykjavík, Hrynczenko, 2010.

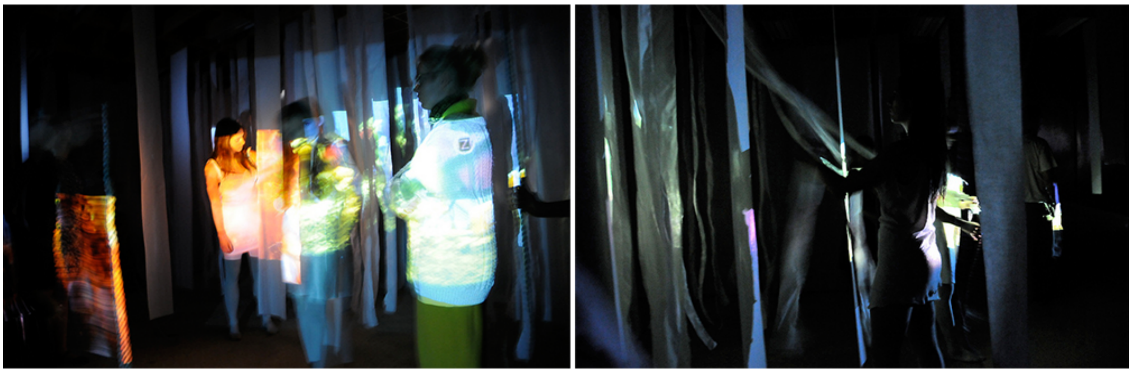


Figure P.0.12 Participatory games; Movement and projections. DAMA workshop Reykjavík, Knuutila, 2010.

Another exercise was based on silhouettes and emotional expressions connected to colour-specific projections.

The three final group projects differed in style and form, however they were all based on the participatory experience. One referred to colours and game experience (figure P. 0.10), another was based on a children's riddle (figure P.0.11) and the third explored movement with colour projections (figure P.0.12). The embodied approach to colour and emotions sparked new conversations among the students and teachers, where the connection between spatiality, corporeality, temporality, and communality was highlighted and fostered new approaches by sharing and exchanging knowledge.

3.3 The 7th DAMA Workshop, Visby

The 7th DAMA workshop at Gotland University in Visby, Sweden (June 6-15 in 2011) was prepared and organised by me in cooperation with Suk-hi Cho, head of the International Office at Gotland University. Since I was coordinating the practical issues, I had the opportunity to firmly establish the core issues of the research into the curriculum planning at both the game department at Gotland University and DAMA network. I therefore had the opportunity to highlight the need to bring performative content into games that include whole body movement. I received great interest from media, theatre and dance representatives and universities within the DAMA Network. As a result, during the workshop new avenues have opened up, involving both ideas from dance performance practice and site-specific games development.

The ten-day intensive workshop focused on the space between dance/theatre and games: Techniques from dance/theatre were applied to the design process of site-specific games and game designs were used to make dance/theatre.

The participating students, eight from media/computer science and seven from dance/performance art came from:

Danish National School of Theatre and Contemporary Dance (Denmark)
Iceland Academy of the Arts (Iceland)
Northern Lithuania College (Lithuania)
Tartu University (Estonia)
Turku University of applied sciences (Finland)
University of Lapland (Finland)

The participating teachers were: Tomi Knuutila, Lecturer in Digital Media, University of Lapland and Albertina Sparrhult, teacher in Game Development, Gotland University. In the introductory phase, Professor Steven Bachelder (Institution of Game Design, Technology and Learning, Gotland University) gave a lecture on site-specific art.

As an result of my pedagogical course, utilising my new knowledge, I have implemented an extended description of the teaching methods and the specification of the outcomes that give an overview of the workshop design. The whole curriculum is part of Appendix H that envelops all of the three workshops curricula.

Teaching methods used during the workshop:

Phase 1: Case studies, learning by teaching, demonstrating (students) panel of experts, lecture with discussion (teachers).
Phase 2: Brainstorming, small group discussion, collaboration (students), coaching (by teachers).
Phase 3: Project-based education, problem-based learning.
Phase 4: Participatory techniques, group-work, problem solving, learning to make positive compromises.

The key people from the Game Department, Gotland University involved in the workshop were the game subject teacher providing an introduction to game development and a teacher in digital media visualisation who gave lectures on site-specific games. Unfortunately, the previous plans that involved practical exercises in the motion capture studio were changed at the last minute, due to the *Mocap capture studio* technician's absence due to unexpected illness. This partly changed the workshop's plans, creating a focus on site-specific and pervasive games and actions and moving the projects from the studio out to the streets of the medieval city of Visby. This way '..the workshop was taken out of the institution building, out in the streets and further even to peripheral, rural areas' (Knuutila, 2011).
With these changes, students could develop a crossover between games and performance using mobile devices, Quick Response Codes (QR) and theatrical techniques, adjusting them to an artistic context in Visby and its surroundings.
At the same time, the framework of action points during the workshop developed into a more extended form:

1) Physical exercises, such as movement sequences: goal-directed functional, expressive-emotional, parallel mirroring, abstract improvisations, rhythmical introvert, rhythmical extrovert, and communicative gestures in pairs.
2) Group trust exercises such as caring and touching, falling, and catching.
3) Common semiotics for physical movement descriptions verbalised during the performed movement.
4) Analyses of the visual movement trace via a virtual mirror, *Shadow Dance*.
5) Simple character-based live games using floor and urban space.
6) Dance with cameras (see body movement trough the camera in real-time).
7) Camera as a first person shooter (see the space through the camera in real-time).
8) Dancing, and running blindfold.
9) Game development theory with focus on site-specific games.
10) Movement sensors, camera, QR-code, mobile phones.

My presentation in the workshop covered the idea of ubiquitous games—that is, games that take place at the intersection of the real world and the virtual world of the game.

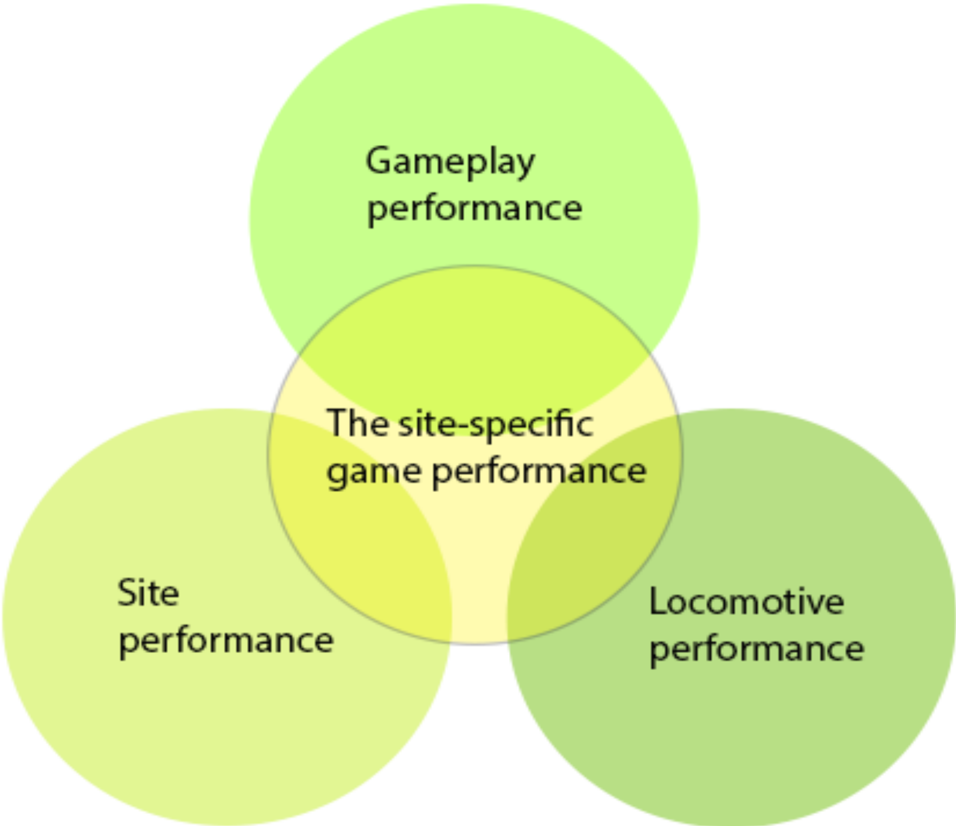


Figure P.0.13 Design based on Kristiansen's site-specific game, Hrynczenko, 2011.

The site-specific game theory (Kristiansen, 2009) was introduced both in the classroom and in the city space using its scenographic value, exploring at the same time the concept of genius loci, spirit of place, and analysed together with the students.
The site-specific game builds on rules for the place, performance and spectators in regards to how they will move in the game (i.e. the locomotion) (figure P.0.13). These rules of the game must integrate with all three parts, and the parameters of which these parts are constituted. Applying the theory in practice, Kristiansen's sets of questions were presented to students according to the three parameters: To define players' movements in the game the following question was asked: How does locomotion make the player progress in the game? However, since the site characteristics affect how players will move, the next question posed was: How do the characteristics of the site influence players' movements?

Figure P.0.14 Trust exercises, DAMA workshop Visby, Hrynczenko 2011.

To make the correlations visible, a new question was posed: How is the site used as a game element? In addition as an inspirational element for the game design, the concept of genius loci was explored as a reference to the unique atmosphere of a place. In conclusion, the final assignment for the students was to explore and define the moods of different places in Visby and connect them via a game play.

Every morning, as a preparatory exercise, analyses of the visual movement trace were applied via a virtual mirror; *Shadow dance*. The morning exercises included trust exercises such as caring and touching, falling and catching, and games where body and movement were experienced collectively. (DVD/Video 6 and figure P.0.14).

I was able to record 80 (10 x 8 emotions) video films of expressive movement. Before each recording session the *Shadow Dance* interactive installation was placed in the studio where participants could explore movement and gesture in an interactive way. This approach was a way to help them focus on bodily movement, used as a 'pre-liminal stage' to the recording sessions.

The students' final projects took different approaches; but all were site-specific placed within the medieval city and its surroundings. One of the games built on keywords connected to location names in the city and photographs of details taken at those specific places. The keywords were generated by miniature photographs of the object that the name was connected with and the name of the place where the photograph was taken, forming both a name of the place and a narrative rebus puzzle. Using a city map and a paper-made compass, found at the new location, the game participants could orientate themselves toward the new site. Each new site provided the participants with a hidden keyword that helped them to unfold the narrative of the game leading them to the final solution. The connected parts of the story were to be solved through different assignments prepared according to the character of each location.

Figure P.0.15 Tournament 3, Visby workshop, Hrynczenko, 2011.

The keywords generated a random storyline that could be approached independently of the order in which the different sites were found. The assignments had different approaches and were formed as small situational tournaments among the participating groups. For example, on the site with a section of the medieval wall with a tower extending into a large lawn, the groups had to choose one member to blindfold and who was then navigated to an object on the lawn through instructions shouted from the tower (figure P.0.15).

The game started with a letter and a mysterious message received from a phone-call via an old-fashioned phone booth located at the first game site. The participating audience became detectives, solving the story with the help of a map and physical assignments to get new information: a mobile number, coordinates, and one letter. This information helped them via mobile phones to navigate four dancers placed in mysterious locations (figure P.0.16), to the final site where previously received letters formed a password allowing them to enter the site where the story concluded with a dance performance (figure P.0.18).

Figure P.0.16 Dancer at site specific performance, Visby workshop, Hrynczenko, 2011.

In the concluding part of the game, all group members (media, game, and dance students) became patients of a medieval hospital playing a story for game participants, who then became spectators in the last phase. The project was announced using flyers on the city walls and at Gotland University, concluding in several tours with public participation in the games.

The second location-based game focused on walks in the city where the narratives were communicated through symbols, texts, and QR codes linked to a specially created website containing historical information about each place based on feature such as location maps (figure P.0.17). This information was available via mobiles that supported a web browser. The historical information provided keywords that added information to the storyline. The real-time activities were designed as individual nodes that appeared in different locations of the city whenever a message, QR code, or image was posted. The participants, who moved in several groups, had to communicate with each other in order to connect the different parts of information that were spread throughout the city but necessary to find the directions on the virtual map leading to real live performances, posters and hidden objects. This setup created a parallel experience to the physical, medieval environment (figure P.0.19).

The game play was based on objects that formed a story leading to future instructions that directly involved the audience in the next level of the game's narrative. The quest culminated in the botanic garden with the final assignment to release a water spirit captured in the pond into the sea. This created a participatory performance where the audience built the chain to transport water in a small container to the sea outside the city's medieval stonewall. The students' aim for the game design was to show in a symbolic and practical way both the value of cooperation and the need for an expanded perspective.

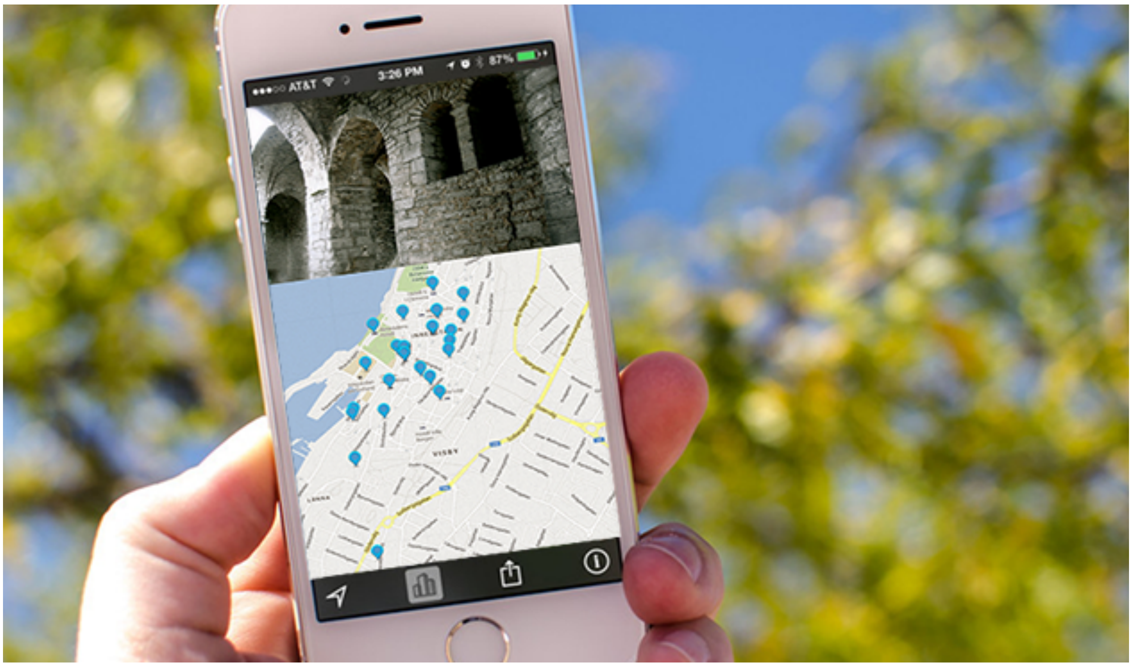


Figure P.0.17 Interface for location map, Visby workshop, Hrynczenko, 2011.

Figure P.0.18 Purganauts The Game, DAMA workshop Visby, Hrynczenko, 2011.

The examples described above illustrate not only the results of the workshop but also the effects of cross-disciplinary cooperation, showing the possibilities that evolve from cooperative assignments when knowledge from games, media art, dance, and performance is combined.

Figure P.0.19 Spill, DAMA workshop Visby, Hrynczenko, 2011.

4 Summary

The workshops are designed as an iterative series of learning loops, where technical programming, artistic ideas, and knowledge are converted into practice in a short time through intensive teamwork. During the workshops, techniques from dance/theatre were used to design new games, and game design techniques were used to make dance/theatre performances. This approach was exemplified in the students' final projects, such as the dancers' movements according to information received via mobile phones and games' assignments based on coordination and movements. The development of innovative concepts of real and virtual theatre and games was a central issue for the assignments, during which the creative working process in the student teams with different backgrounds was the focus. This method illustrates a collective experience through a shared encounter, providing a basis for knowledge exchange and new pedagogical and artistic methods where focus is on the process not the final result.

The finalised student projects illustrated the possibilities of different forms and expressions that arise from cross-disciplinary environments. Most of all, the positive results highlight the need for cross-disciplinary elements in education and research. Within the scope of this doctoral study, the workshops have provided a creative research setting and the opportunity for expressive movement documentation, where students voluntarily participated in the documentation of emotional movements. Beyond the opportunity to develop different pedagogical methods, the workshops made it possible to collect visual data such as video documentation and metric data based on questionnaires. These provide a foundation for the PTM database as well as a forum for discussions and feedback, all essential for the database creation.

The DMA workshops become a laboratory where game play, site-specific performance, mobile, and Internet technology was explored in the context of the human body in action. The physicality of games in a site-specific context used technology in an active way (i.e. in terms of bodily engagement). The students' game design incorporated concepts from site-specific game design including locomotive performance in a social context. From my research point of view the fundamental 'lifeworld' themes founded on phenomenological human science research: spatiality, corporeality, temporality, relationality or communality (van Manen, 1990) was explored in the context of games.

Appendix R

List of Complementary Video Material on DVD

Video 1
Video documentation from Shadow dance exhibition at Visual Research Centre/ DCA (Dundee Contemporary Arts) (in text p. 226) 206

Video 2
Process of conversion of the video material to silhouettes. (in text p. 217)

Video 3
Documentation, example of the use of the *Shadow Dance* installation by participants. (in text p. 221)

Video 4
Presentation of the database site (in text p. 277)

Video 5
Students' project *Sushi makes me happy* explores movement, sound, sensory input and graphics (in text p. 431)

Video 6
DAMA workshop, preparatory exercise, body and movement based games (in text p. 438)

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